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INVENTORY AND REVIEW OF ECONOMIC AND COMMODITY FORECASTING MODELS AND SERVICES

APRIL 1993

Ontario

Ministry of
Environment
and Energy

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APRIL 1993

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INVENTORY AND REVIEW OF ECONOMIC AND COMMODITY FORECASTING MODELS AND SERVICES

Report prepared for:

Economics Office
Policy Development and Intergovernmental Relations Division
Ontario Ministry of Environment and Energy

Report prepared by:

APOGEE Research International

TABLE OF CONTENTS

1.0 Background and Purpose 1

2.0 Methodology 4

3.0 Overview of Results 6

4.0 Iron and Steel 7

5.0 Petroleum Refining 8

6.0 Organic and Inorganic Chemicals 9

Model of Economic-Energy-Chemical Interactions (Probe Economics Inc.) 10

7.0 Pulp and Paper 13

FORGEM 1.0 (Forestry Canada) 14
Econometric Model of the Pulp and Paper Industry (Ministry of the Environment) 17

8.0 Metal Mining 22

Secondary Supply of Copper and Ferrous Metals (Centre for Resource Studies) 24
Resource Strategies Inc. 26
Brook Hunt & Associates Limited 30

9.0 Industrial Minerals 31

10.0 Metal Casting 32

11.0 Energy and Electric Power Generation 33

Ontario Ministry of Energy 36
Ontario Hydro 39
Transportation and Residential End-Use Energy Demand Models
(Energy, Mines and Resources) 43
Industrial Sector Technology Use Model (Energy, Mines and Resources) 46
Interfuel Substitution Demand Model (Energy, Mines and Resources) 49
Integrated Model of Alberta (Energy Resources Conservation Board) 52
SERF, MARKAL and Marbek Resources 55

12.0 Recreation and Tourism 59

Interactive Model of Recreational Activities
(Ontario Ministry of Tourism and Recreation) 61
Ontario Forecasting Model of Tourism Demand
(Ontario Ministry of Tourism and Recreation) 63
Model of Beach Use and Environmental Quality
(Ontario Ministry of the Environment) 66
Acid Precipitation and Recreational Fishing Activities
(Ontario Ministry of the Environment) 68
Forecasting Activities at the Canadian Parks Service
(Canadian Parks Service) 70
Tourism Forecasting Models
(Canadian Tourism Research Institute) 72
Outdoor Recreation Demand Forecasting Model
(David Foot) 74

13.0 Macroeconomic Models 76

DRI (Data Resources/McGraw-Hill) 78
Federal Government Models 84
FOCUS (Institute for Policy Analysis) 86
MACE (Helliwell) 91
MTFM (Conference Board in Canada) 93
Informetrica 98
WCCM (WEFA Canada) 102

14.0 U.S. Models 107

Data Resources/McGraw-Hill 108
WEFA 113
Forecasting in the EPA Economic Impact Analyses 116
Hartman, Bozdogan and Nadkarni (1979) 117
Hazilla and Kopp (1990) 120
Jorgenson and Wilcoxen (1990) 123
Strategic Environmental Assessment System/Resources for the Future 127

Appendix A Bibliography

Appendix B Contact List

Appendix C Industrial Detail of the Canadian Macroeconomic Models

Appendix D CEEF Model - Slides

1.0 Background and Purpose

Background: Economic and Commodity Forecasting Models

Economic models consist of one or more equations which estimate the values of endogenous economic variables as functions of exogenous variables.

Economic models are used for a variety of purposes. Three of their most important uses are:

- forecasting: predicting the future values of economic variables;
- simulations: estimating the effects of shocks upon economic activity; and
- testing economic theory: constructing models to verify hypotheses regarding the way economic forces are determined and interact.

Such models may be useful to environmental policy makers for similar reasons. Specific applications of models to environmental policy issues include:

- forecasting emissions by applying emissions factors to production forecasts;
- simulating the economic effects of environmental protection measures upon regulated industries; and
- estimating the potential benefits of environmental regulations in terms of tourist and recreational activities.

Each of these applications demands models with certain attributes, perhaps the most important of which is their level of aggregation. The most highly aggregated macroeconomic models may include only one production function for the entire Canadian economy. Since these models were constructed in order to estimate the impact of various public policies on the macro economy, they are able to simulate some of the effects of environmental protection policies on a wide range of economic variables. However, forecasts of output effects at the economy-wide level are likely of limited use in predicting contaminant emissions or discharges.

Other models provide estimates of output at the sectoral level. Since environmental protection regulations impact very differently upon different sectors, sectoral detail is essential for many purposes, including those mentioned above.

However, even output at the industrial sector level may be too highly aggregated for some of the Ministry's purposes. Since industries are generally defined to encompass at least several products, substantial variation in contaminant discharges may exist between production units within each sector. For example, a model of the pulp and paper industry may disaggregate the sector by production of newsprint, woodpulp, paperboard, etc. A separate emissions coefficient for each product would allow forecasts of total contaminant discharges to fluctuate with the *composition* of each sector's output.

A final level of disaggregation, namely by type of production process, has also been shown to be significant in projecting emission loadings. Significant differences in emissions often occur as a result

of differences in technology employed. This implies that the ideal data set to forecast contaminant emissions should also include commodity forecasts by production process.

The Ministry's Use of these Models

The Ministry uses economic and commodity forecasting models for two main purposes:

- to simulate the economic effects of environmental protection measures upon regulated industries and other sectors; and

- to forecast emissions of pollutants of concern by applying emissions factors to predicted production, with the production forecasts being derived (implicitly or explicitly) from economic and/or commodity models.

An example of the first use is the Ministry's analysis of the effects on the Ontario pulp and paper industry of increased environmental protection measures.

An example of the second use is presented in Exhibit 1.1, which is a simplified overview of how the Ministry's Air Resources Branch estimates current and future emissions of interest. It is in step 5 of this exhibit that Ministry staff estimate the future emissions of pollutants, and it is this step that could benefit from the use of economic and commodity forecasting models.

Purpose

The range of macroeconomic and commodity forecasting models which could potentially be used by the Ministry is quite broad. Moreover, the uses, applications and complexities of these tools have been increasing rapidly. What the Ministry requires is a clearer understanding of the availability and nature of existing models so it can better utilize existing information sources.

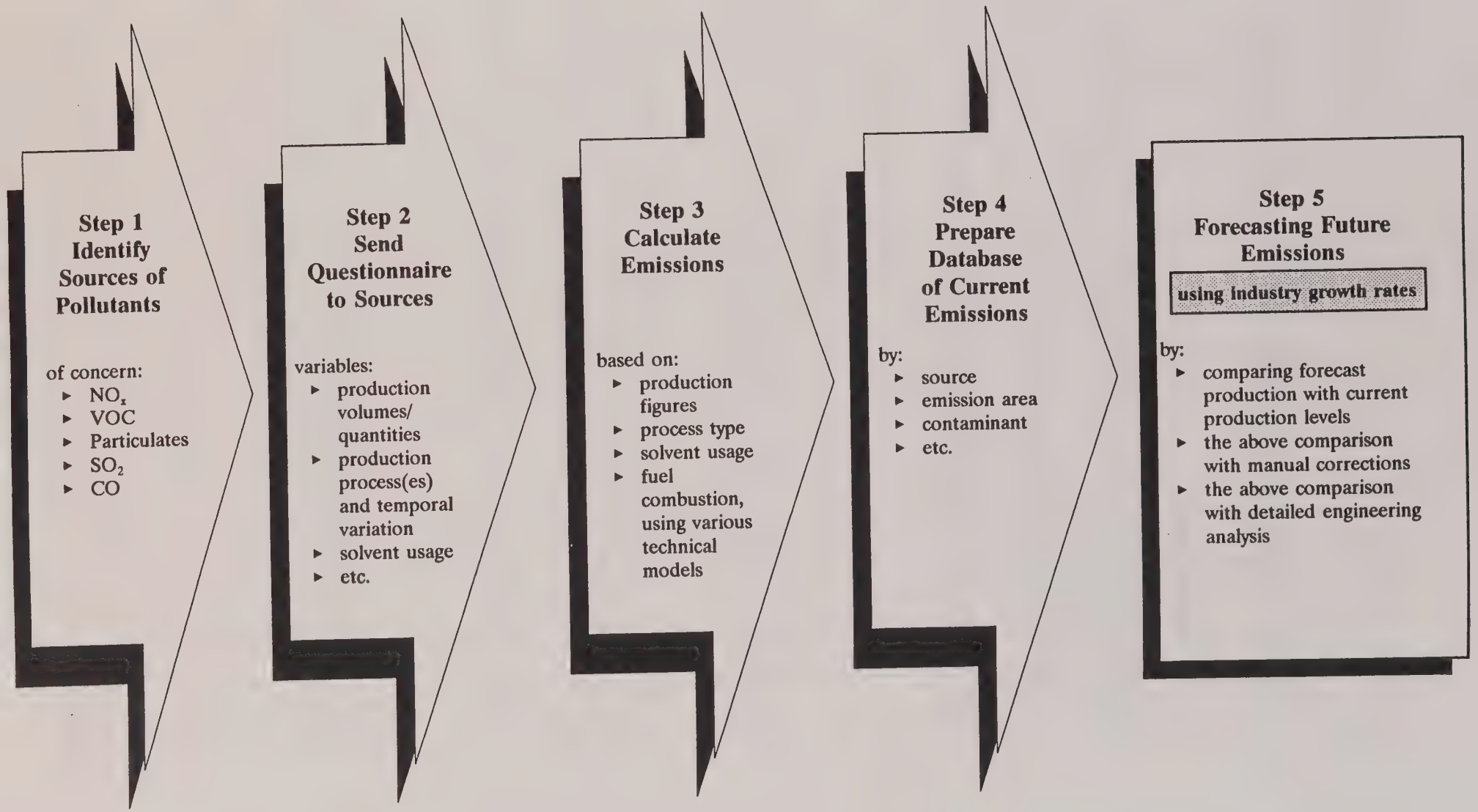
The purpose of this project is twofold.

- It provides an inventory of economic and commodity forecasting models which could or do incorporate relevant variables and data relating to Ontario (ie. economic, environmental, energy and tourism).

- Second, it assesses critically a selected number of these models in order to provide the Ministry with a clear understanding of the attributes of the models most closely suited to the Ministry's needs.

As a result, Ministry personnel will be better able to utilize the models to further their environmental economic evaluation needs.

Exhibit 1.1
Air Resources Approach to Forecasting Air Emissions



This report describes and assesses the models available to the Ontario Ministry of the Environment. It provides an overview of the models available for ten Canadian sectors, selected in consultation with the Ministry. These industries comprise:

- iron and steel;
- petroleum refining;
- organic and inorganic chemicals;
- pulp and paper;
- metal mining;
- industrial minerals;
- metal casting;
- energy and electric power generation; and
- recreation and tourism.

In addition, the report examines models of the Canadian macroeconomy and selected economic models used by the U.S. Environmental Protection Agency.

2.0 Methodology

The first stage of this project involved three activities: model identification, collection and analysis of information and reporting results. Each is briefly outlined below.

Model Identification

The team of consultants used a variety of sources to develop a list of pertinent models or potential sources of pertinent models. This was developed through an extensive literature review and interview program. The interview program encompassed:

- government officials in an assortment of provincial and federal ministries and agencies;
- leading academics in related fields;
- research institutions;
- industry associations; and
- private firms.

A list of contacts is provided as an appendix.

Collection and Analysis of Information

Model proprietors were formally requested for information regarding modelling capabilities and structural details. Where possible, we have obtained full user manuals. In most cases, however, we have had to rely upon brief model descriptions contained in applications of the models or marketing brochures.

Two important caveats to the information upon which this report is based must be noted. First, the information provided by model proprietors has been taken at face value. Few attempts to verify the information have been made. For some models, such as those in the public sector, this may not result in distortions. However, for some private modelling firms, the information provided differed significantly from the expectations of some independent forecasting analysts.

Second, all model proprietors have not verified our analysis of their models. The discussion presented in this report may not coincide with what proprietors would report to the Ministry.

Reporting of Results

The model discussions are organized around an information "shell." This shell consists of various categories of information of interest to the Ministry. Unfortunately, information for the complete shell is rarely available for any individual model. The analysis incorporates as much information as was readily available. Where necessary, the shell has been modified.

Exhibit 2.1 provides an overview of this shell.

Exhibit 2.1
The Information Shell

1. **General Information**

    - purposes of the model
    - main users
    - ownership
    - brief history of development

2. **Structure of the Model**

    - key functional relationships
    - inputs
    - time period over which model is estimated

3. **Outputs**

    - economic and/or commodity forecasts
    - frequency of forecasts
    - time period over which forecasts are made

4. **Other Worthwhile Information**

5. **Usefulness**

    - for economic and/or commodity forecasts
    - for forecasting emissions, effluents, or solid wastes
    - availability to the Ministry

3.0 Overview of Results

The bulk of this report is a model-by-model discussion of our findings. The models are described in separate sections for each industrial sector, macroeconomic models and selected U.S. models. However, it is useful to begin with an overview of our major findings.

First, substantial variations in modelling activity were found between different sectors. Some broad generalizations can be made regarding these sectoral findings.

- Governments play a major role in modelling sectors in which they heavily intervene. Perhaps the clearest example of this is the energy sector. Not only are rates of return and construction of new facilities regulated, but the strategic importance of the sector has motivated governments to implement programs such as the National Energy Policy and various conservation initiatives. Federal and provincial governments maintain extensive in-house models for the energy sector.

- Governments play a major role in modelling sectors which they heavily support. Tourism and recreation are two particular examples. Governments provide grant programs for recreational infrastructure, operate recreational facilities themselves and engage in marketing activities for the sector. In addition, they are the major source of tourism and recreational forecasting models.

- Many firms in the industrial sectors most adversely affected by recent recessions have undergone rationalization programs which included reducing the size of their economic analysis units. Few private firms in these sectors continue to maintain in-house forecasting models. Indeed, many expressed complete lack of faith in results produced by such models. This sentiment was also found among consultants catering to industrial sectors. Few consulting firms rely on formal forecasting models.

Second, sources varied greatly in the extent to which they were willing to cooperate with the goals of this study. Not surprisingly, private industrial firms were much more reluctant to reveal details of their forecasting activities than government branches. Consulting firms, which earn their living from proprietary knowledge of their analytical capabilities, were also reluctant to provide any information beyond standard marketing material.

Third, it was discovered that models pertaining to specific sectors are quite similar at the surface level. This is most apparent with macroeconomic models. In order to differentiate between these models, it is necessary to present significant amounts of technical detail. Within the resource constraints of this project, much elaboration on general background information pertaining to economic modelling is not possible. In future stages of this study, recommending most appropriate models for the Ministry's purposes, analysis of an even more highly technical nature will be necessary.

Unfortunately, this necessary emphasis upon technical material may limit the accessibility of this report. Non-economists will have difficulty understanding several sections of the report. It is expected, however, that such readers will have access to expert economic advice through the Ministry's specialist staff.

With these brief points in mind, we now turn to the detailed findings for each sector, macroeconomic models and U.S. models.

4.0 Iron and Steel

The iron and steel and metal mining sectors are closely linked. Therefore, much of the research of the two sectors overlaps and as such, the models described in the metal mining sector also, for the most part, apply to iron and steel as well.

Described here are the organizations contacted in efforts to identify relevant forecasting models.

- *Resource Strategies Inc. (RSI)* (not to be confused with Resource Information Systems Inc.) provides forecasting services for the steel sector as well as for metals. However, no specific information on their steel sector modelling was provided.

- *The Canadian Steel Industry Research Association* does not employ forecasting models. The models which the Association felt were applicable to the iron and steel sectors were those run by Informetrica (described elsewhere in this report) and Paine Webber's U.S. model.

- *Dofasco* attempted about a decade ago to develop a model for the iron and steel industry but were unsuccessful. Their forecasting involves taking general economic forecasts produced by various agencies, incorporating demographics, interest rates, employment levels etc, and splitting their products into different market segments. From this a range of demand possibilities is produced.

A review of *Primary Commodity Markets and Models: An International Bibliography*[1] indicated that the development of models both by industry and academics for the iron and steel sector was performed about 15 years ago. The vast majority of the models are, at least, a decade old and have not been updated since their creation.

1. Labys, Walter C., *Primary Commodity Markets and Models: An International Bibliography*, Gower Publishing Company, USA, 1987.

5.0 Petroleum Refining

A host of associations and energy organizations were contacted in an attempt to find pertinent models. The models which were found are described in the energy, chemical or macroeconomic sections.

- *SRI*, described in the chemicals section, provides forecasts on the petroleum refining industry. However, they were not willing to provide documentation on their models.

- *Imperial Oil* primarily employs engineering models (ie. input-output) in forecasting demand for petroleum products. The information on these models is not available to outside personnel.

As indicated, the petroleum refining industry is covered by the models described in the energy and chemical sections. Therefore, no models are described in this section.

6.0 Organic and Inorganic Chemicals

Very few models were found for organic and inorganic chemicals. The only relevant models identified were those of DRI, Probe Economics and SRI. (DRI's model is described elsewhere in this report.) Before describing individual models, some of the government agencies and private firms contacted are outlined.

- *The Canadian Chemical Producers' Association (CCPA)* tracks historical data on the chemical industry but does not provide any forecasting services. However, they utilize the information provided by DRI in analyzing the marketplace.

- *The Ontario Ministry of International Trade and Technology* does not employ forecasting models.

- *Industry, Science and Technology Canada* also does not employ any models. They utilize the information from several private firms: SRI, DRI and Probe Economics.

- *SRI* runs economic models for the petrochemical industry. However, the only information they were willing to share was during a short telephone conversation. SRI maintains a huge database which provides historical demand by end use, by chemical, for various international regions. The information is used to build markets from the ground up in their modelling efforts. Subjective adjustments are made to the model results by SRI analysts. Besides this brief description of their work, SRI would not provide any further documentation.

- *Probe Economics*, based in the U.S., runs a variety of forecasting models in analyzing the chemical industry. Their most sophisticated model, the model of Economic-Energy-Chemical Interactions is briefly described in this section.

- *Corpus Inc.* provides market research services for the chemical industry in Canada. While they publish forecasts of prices, production etc for the chemical industry no formal model is employed in doing so. Rather, close contacts with the industry, analysis of end-use markets and the use of externally generated economic data are used for predicting future trends in the industry.

Therefore, for the chemical industry little modelling is currently being performed.

Model of Economic-Energy-Chemical Interactions[2] [Probe Economics Inc.]

1.0 GENERAL INFORMATION

Probe Economics is a private firm offering forecasting and market research services in chemical and energy related industries. They employ a collection of models to conduct analyses on the U.S. and foreign chemical industries. Clients may either subscribe to their regular forecasting service or hire Probe to customize their models for a particular use. An example of their recent work is a study entitled "Chemicals, Energy and Economic Growth: Competitive Strategies for Changing World Markets".

The Model of Economic-Energy-Chemical Interactions is Probe's most sophisticated. It is briefly described below.

1.1 Purposes of the Model

The model follows the interactions among the world's energy, chemical and general economic sectors and shows the affect on volumes, prices, and profitability of various external events.

1.2 Main Users

Chemical, oil, pharmaceutical and paper industries; financial firms; and trade associations.

1.3 Ownership

The model is owned and maintained by Probe Economics.

1.4 Brief History of Development

Probe Economics has specialized in economic forecasting and market research since 1974. They have developed a variety of forecasting models to use in their analyses, of which the Economic-Energy-Chemical is the most sophisticated.

2.0 STRUCTURE OF THE MODEL

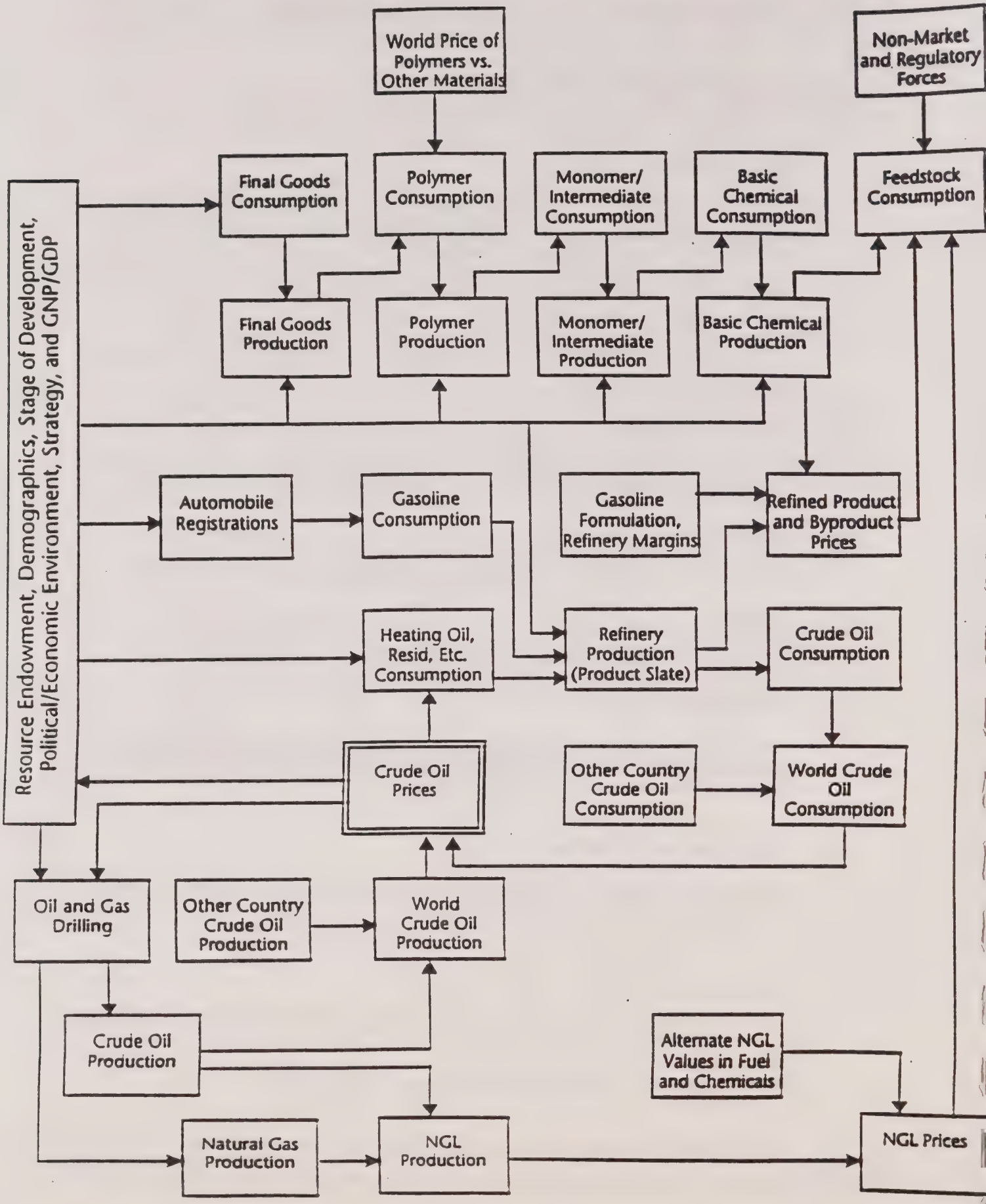
The figure on the following page illustrates the functional structure of the model. It is based on fundamental demand-supply theory.

---

[2] Probe Economics (1991) "Probe's Model of Economics-Energy-Chemical Interactions" Millwood, New York.

Contact: Frederick Peterson, President, Probe Economics. (914) 923-4505

Probe Model of Economic-Energy-Chemical Interactions



Probe studies the interactions among the world's energy, chemical and general economic sectors in forecasting for the chemical industry. The effect of the economy on energy, the effect of energy on chemicals and the effect of economy on chemicals, and vice versa for each, are studied.

2.1 Time Period Over Which Forecasts are Made

The forecasts prepared by Probe extend to the year 2001.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

The models predict the supply, demand, price, and profitability for individual sectors within the chemical industry.

3.2 Frequency of Forecasts

The model is used for a variety of purposes. The regular forecasting service of Probe is published twice a year. (These forecasts extend only 2 or 3 years into the future.)

3.3 Capability to Forecast Outputs by Specific Facilities Within Specific Industry Groups in Ontario (i.e., Ontario Applicability)

Probe's capability to forecast outputs at specific facilities within specific industry groups is unknown. However, they do customize their models for individual clients and are able to incorporate different sources of data into their models.

4.0 OTHER WORTHWHILE RELATED INFORMATION

Computerized data and forecasts are available for use on IBM-PC compatibles on Lotus 123.

Probe also has forecasting models for over 70 specific organic chemicals, polymers, inorganic chemicals and other chemicals.

Probe has focused a component of their research on assessing the effects of environmental and regulatory issues.

4.1 Availability and Cost

Probe is a private firm offering a variety of services. The cost of tailoring this model for a specific client could vary widely depending on the particular needs of said client.

5.0 USEFULNESS

5.1 As A Source For Macro/Commodity Forecasts

The model provides forecasts for a variety of chemical, energy (ie. gasoline production) and economic variables. The model is also able to simulate some effects of various environmental and regulatory forces. However, it is not possible to assess the usefulness of these forecasts from the information provided by Probe.

7.0 Pulp and Paper

Several relevant models were identified for the pulp and paper sector. Before describing these individual models an outline of some of the organizations contacted is provided.

- *The Canadian Pulp and Paper Association* does not run any models themselves at the present time. Models have been run in the past to estimate demand for newsprint in the U.S. but these models were notoriously inaccurate and were discarded. The Association also mentioned that no firms in the industry were using models for forecasting, relying rather on general economic forecasts and industry knowledge to plan for the future.

- *MacMillan Bloedel* and *Stone Consolidated* rely on industry knowledge and market research in forecasting future demand for paper products.

- *The Ontario Ministry of Natural Resources (MNR)* currently has a Request for Proposals out for the development of a forest products forecasting model. They do not presently have a model which is suitable for their purposes and intend to fund an outside firm to develop and maintain this model. Past work for the Ministry has been performed by Resource Information Systems Inc. (RISI).

- *RISI* runs models for the pulp and paper industry, as well as for lumber and plywood. They are willing to provide information on the work they have done for the MNR conditional on Ministry approval. The scope of the work RISI performed for the MNR is presently unclear. RISI did not provide any information on their modelling efforts.

- *Forestry Canada* runs several models, the most sophisticated of which is a general equilibrium model named FORGEM (FORest General Equilibrium Model). The model is described in this section.

- The other model described in this section was prepared by the *Ontario Ministry of the Environment* by Mike Fortin, based on the original work of R.A. Muller. The model estimates the economic effects of pollution abatement on the pulp and paper industry in Ontario and for Canada as a whole.

A General Equilibrium Model of the Canadian Forestry Industry (FORGEM 1.0)[3] [Forestry Canada]

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

The model provides a framework for the analyses of trade and forest policies that affect the Canadian forest industry.

1.2 Main Users

Government policy makers, industry.

1.3 Ownership

The model is owned and maintained by Forestry Canada.

1.4 Brief History of Development

The importance of the forestry industry to Canada's economy prompted the development of a framework for analyzing the factors which influence Canada's competitiveness in international markets. FORGEM was developed by Robert Prins, an economist with Forestry Canada, to perform this function.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

FORGEM is a short-run, inter-sectoral, inter-regional model (ie. it recognizes the interactions between regions and between sectors within a region) specified in proportional rate of change format. Relative prices, factor endowments and production technologies are used to describe the economy.

The Canadian forest industry is divided into five regions and sectors. The regions are BC (BC coast), BI (BC interior), PR (Prairies), CE (central), AT (Atlantic). Sectors are: LO (logging), SM (sawmilling), PU (pulping) NP (newsprint) and OP (other paper).

---

[3] Prins, Robert G. (1990) "A General Equilibrium Model of the Canadian Forestry Industry (FORGEM)" Ottawa: Forestry Canada.

Contact: Robert Prins, Forestry Canada.

In international markets, Canada is considered as an excess supplier of lumber, wood pulp, newsprint and other paper products. Regional production of forest products is destined for the U.S., Japan, European Community and domestic Canadian markets. The U.S., Japan and the EC are considered to be excess demand regions with the European Free Trade Association (EFTA), Latin America, and other Asia-Pacific providing alternative supplies of forest products.

Final demand is modeled using the Armington assumption that products differing only in place of origin are imperfect substitutes. The Armington assumption represents two characteristics of forest products' trade. First, forest products originating from different areas are not exactly the same. Differences in the timber used to produce forest products results in differences in the quality and characteristics of the these forest products. Second, established trade patterns for forest products are sometimes resistant to changes in the prices of forest products. This trade inertia results from the fact that fewer problems are typically encountered when established trade patterns are followed. Establishing new trade flows has an added cost in the uncertainty and problems encountered in dealing with a new situation. Therefore, forest products originating from different regions should be considered, for modelling purposes, as imperfect substitutes.[4]

Primary input demands are modeled using constant returns to scale, constant elasticity of substitution and homothetic functions. Intermediate commodity input demands are modeled using constant elasticity of substitution.

Multiple output supplies are modeled using constant elasticity of transformation functions. Individual supply outputs are modeled using a simple output supply function where output is a function of output and input prices.

2.2 Estimation Period/Approach/Inputs

All data is annual and derived from the base year 1986. The model draws its data from several Statistics Canada publications, *Selected Forestry Statistics*, published by Forestry Canada, and the *FAO Yearbook of Trade in Forest Products*.

Endogenous Variables include: the price of timber, the price and quantity of pulpwood, the price and quantity of sawlog, the quantity of labour, the quantity of energy, the price and quantity of wastepaper, newsprint, and other paper, and the price of capital.

2.3 Time Period Over Which Forecasts are Made

No forecasts are made.

---

4 Prins, R.G. (1990). "A General Equilibrium Model of the Canadian Forestry Industry (FORGEM 1.0) with an Application to Japanese Tariff Barriers" Ottawa: Forestry Canada, Working Paper, page 9.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

The model estimates the effect on the Canadian forestry products, by region, of trade and forest policies.

3.2 Frequency of Forecasts

FORGEM is used to analyze specific trade and/or forest policy issues on an as-needed basis.

4.0 OTHER WORTHWHILE RELATED INFORMATION

The model is set up on a Lotus 123 spreadsheet and is solved by matrix manipulations. These manipulations are performed using a FORTRAN program.

5.0 USEFULNESS

5.1 As A Source For Macro/Commodity Forecasts

FORGEM can be used for simulating a wide range of policy shocks on a regional, national and international basis. As Ontario comprises the majority of the Central Region, effects of different policies on the forest industry can be estimated for the province.

However, the model needs to be expanded in geographical detail to better account for the international nature of Canada's forest industry. It should also be expanded to account for the linkages between the forest industry and other Canadian economic sectors[5].

5.2 For Forecasting Emissions, Effluents and Solid Wastes, and For Estimating the Impacts of Environmental Regulations

The model incorporates production technology as an exogenous variable. Therefore, forecasts could be prepared using coefficients which link production technologies and production levels to emissions, effluents and solid waste.

---

[5] Robert G. Prins, *Working Paper, A General Equilibrium Model of the Canadian Forestry Industry (FORGEM 1.0) with an Application to Japanese Tariff Barriers, 1990, p.ii.*

Econometric Model of the Pulp and Paper Industry[6] [Ontario Ministry of the Environment]

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

The model is used to forecast the impacts of environmental and regulatory issues on the Canadian and Ontario pulp and paper industry. In this case it is used to assess the impact of pollution abatement expenditures on production, employment, prices and capacity growth in the pulp and paper industry.

1.2 Main Users

The Ontario Ministry of the Environment.

1.3 Ownership

The Ministry.

1.4 Brief History of Development

The Ontario Ministry of the Environment established a series of "Working Papers in Environmental Economics and Planning" in 1980. The series was intended to disseminate research on the economic and social aspects of environmental issues. The report which was prepared from the results of running the pulp and paper industry model was the first in this series.

The model, originally designed by R.A. Muller[7], was revised and updated by Mike Fortin, in order to analyze the effect of pollution abatement costs on the pulp and paper industry in Ontario and Canada.

---

6 Fortin, M. (1980) "The Economic Effects of Pollution Abatement on the Pulp and Paper Industry: Results of an Econometric Study" Toronto: Ontario Ministry of the Environment.

Contact: Jack Donnan, Fiscal and Economic Analysis, Ontario Ministry of the Environment.

7 R.A. Muller (1975) "A Simulation of Adjustment to Pollution Control Costs in the Pulp and Paper Industry", Unpublished Thesis, University of Toronto.

2. STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The figure on the following page presents the underlying rationale for this model. The arrows represent the causal links hypothesized for the pulp and paper industry.

Variables within the dashed line are endogenous and those outside exogenous.

The model utilizes a fixed coefficient production function, demand and market share functions, and a fixed mark-up pricing mechanism. The model is made dynamic by "the imposition of a partial adjustment process in price setting and variable factor demand and by the use of a Koyck and a Pascal distributed lag structure for the demand of fixed capital".

The model divides industry products into four groups for Canada:

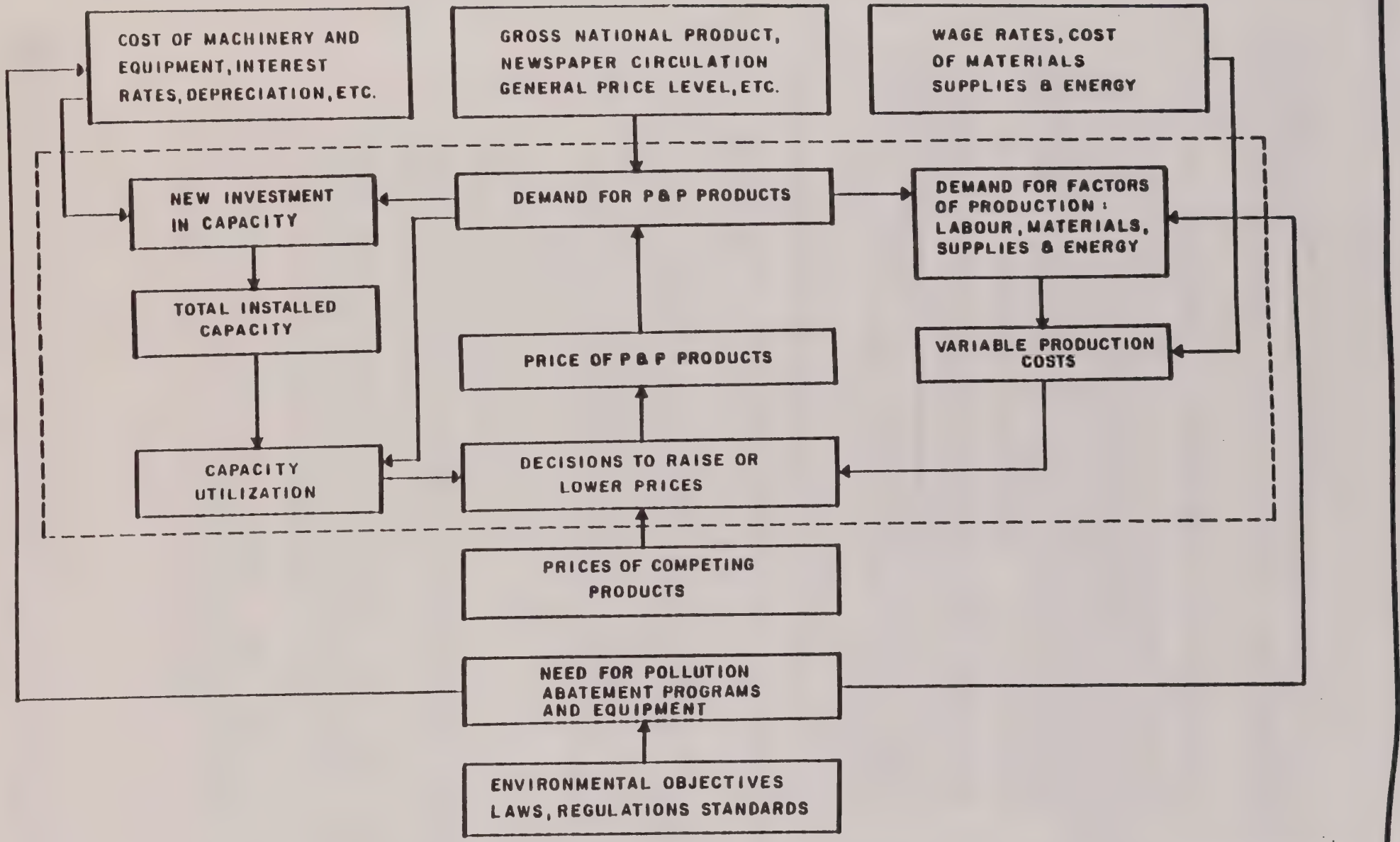
- newsprint (45 % of total output);
- woodpulp exports (25 %)
- other pulp and paper board (23 %); and
- other products (7 %).

Industry products are divided into three categories for Ontario:

- newsprint (32 %);
- other paper and paperboard (38 %); and
- other products including woodpulp exports (30 %).

Four measures of capacity are used:

- American newsprint capacity;
- Canadian newsprint capacity;
- Canadian woodpulp capacity; and
- Ontario newsprint capacity.



AGRAM I : SCHEMATIC REPRESENTATION OF THE PULP AND PAPER INDUSTRY BASED ON MULLER'S MODEL

Source: The Economic Effects of Pollution Abatement on the Pulp and Paper Industry, 1980.

Two other measures of industry factor inputs are:

- labour; and
- a composite index of the consumption of materials, supplies and energy.

The model assumes that newsprint is sold in a common North American market, woodpulp exports are directed primarily to the U.S. and paperboard products are sold in domestic Canadian markets.

The newsprint and Canadian paper and board markets are considered to be oligopolistic in nature. Therefore, a price leadership model is used in specifying the price equations. Woodpulp, on the other hand, competes in a tariff-free world market, and the price equation is determined through supply-demand interactions. Woodpulp exports are assumed to be determined "simultaneously with the unobserved Canadian net prices and world demand for North American woodpulp."

The model is dynamic in that it allows the events of past years to influence current activities.

2.2 Inputs/Estimation Period

Exogenous variables include: average hourly earnings in pulp and paper mills, average and in Ontario; exchange rates between Canada and the U.S.; Canadian Gross National Expenditures (GNE) in 1961 dollars; Canadian and U.S. user cost of capital in paper and allied industries; price index for other papers and board, U.S.; wholesale price indices; and Canadian price of imports of other paper and board.

The model was estimated over the period 1958-1974.

2.3 Time Period Over Which Forecasts are Made

No forecasts are made.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

The model estimates the effects on Ontario's and Canada's pulp and paper industry of pollution abatement costs.

Endogenous variables include: Canadian, Ontario and U.S. newsprint capacity; Canadian woodpulp capacity; industry selling price for woodpulp, newsprint and other paper and board; Canadian and Ontario pulp and paper mill production workers; production of newsprint in Ontario and Canada and North America; Total North American woodpulp production; Ontario woodpulp production; value of shipments of the Canadian and Ontario pulp and paper and newsprint industries; and, total variable costs per unit of production for Canada and Ontario.

3.2 Frequency of Forecasts

The model is not run on a regular basis.

3.3 Capability to Forecast Outputs by Specific Facilities Within Specific Industry Groups in Ontario (i.e., Ontario Applicability)

A detailed analysis of the Ontario pulp and paper industry, broken out by three product categories, is provided by the model. It does not forecast outputs by specific facilities. However, given the limited number of pulp and paper firms in the province it may be possible to estimate the outputs from individual facilities with a modification of the model.

The model does not take into full account competition between Ontario and Canadian producers. (However, it was recommended in the report proposed by Fortin that future work take into account this competition between Ontario and Canadian producers.) Therefore, the analysis of findings relating to Ontario should be regarded with caution.

4.0 OTHER WORTHWHILE RELATED INFORMATION

None

5.0 USEFULNESS

5.1 As A Source For Macro/Commodity Forecasts

The model is able to analyze the effects of cost changes on the pulp and paper industry in Ontario, Canada and North America.

5.2 For Forecasting Emissions, Effluents and Solid Wastes, and For Estimating the Impacts of Environmental Regulations

No attempt is made to forecast emissions. However, this is one of the few models which has been used to investigate the effect of environmental regulations.

8.0 Metal Mining

Unfortunately, while many models were identified for the metal mining sector we were only able to acquire information on a few. There are several reasons for this. First, many of the models are outdated, being produced as far back as 1944. Secondly, it was discovered that use of models in the metal mining sector has diminished significantly over the last decade, both in the public and private sector. Models have been abandoned due to inaccuracies in their forecasts and because of the resource required to maintain them. Last, the models which were recommended by the majority of the contacts are owned by private firms. These firms were willing to provide a general overview of themselves and their models, but detailed information was not available.

In addition, many of the macroeconomic models (Informetrica, DRI, etc.) provide forecasts for the metal mining sector. These models are described elsewhere in this report.

Before describing individual models, some of the government agencies and private firms contacted are outlined.

- *Energy, Mines and Resources* (Economic Policy Group) publishes a quarterly document entitled "Canadian Mining and Metallurgy: Trends and Short term Outlooks."[8] However, the group does not employ a model in preparing this document. The Statistics and Modelling Branch indicated that they used to run a model in the early 1980's but have since abandoned it due to the cost of upkeep.

- *Industry, Science and Technology Canada (Metals and Mining Division)* does not run any forecasting models. They do, however, utilize information provided in forecasts prepared by private firms such as Informetrica, Resource Strategies Inc, and Brook Hunt to prepare market analyses.

- *The Ontario Ministry of Northern Development and Mines* (then part of the Ministry of Natural Resources) had developed a model in the early 1980's but have, as with EMR, has abandoned its use due to the cost and labour involved with maintaining it. The objectives of the model was: to analyze the fundamental determinants of prices and the production and consumption of several mineral resources; to generate simulations of future values of production, consumption, and price. The model derives supply and demand equations for particular commodities, and from this derives a price function. It then predicts future supply, demand and future prices for periods up to 10 years. The last update of this model was performed in 1982. Greater detail on this model is available if desired.

- *Resource Strategies Inc. (RSI)* is a private firm based in the U.S. which provides consulting and forecasting services to the metals and minerals sector. A brief description of their chrome market model is provided in this section.

8 Energy Mines and Resources (1991) *Canadian Mining and Metallurgy: Trends and Short term Outlooks.*

- *Brook Hunt*, a private firm based in England, provides services similar to those of RSI. Brook Hunt maintains an extensive database of industry information, but there modelling is limited primarily to cost of production spreadsheets for individual organizations or facilities. A brief description of their spreadsheet for zinc mines is included in this section.

- *NickData*, based in Toronto, specializes in the nickel market, price levels, production levels etc. In the past, NickData has attempted to develop a model for the nickel market. However, their attempts have met with little success in accurately capturing the numerous variables affecting the market.

- *The Centre for Resource Studies (Queen's University)* has developed a model entitled "Secondary Supply of Copper and Ferrous Metals and Canadian Metal Markets." A description of the model is included in this section. This is the only model for the metal mining sector which has been developed by the Centre.

- *First Marathon Securities, Brian Felske and Associates, Mclean Mcarthy*, all investment analysts, not only do not employ models, but are adamantly opposed to their use.

Discussions with academics at several institutions indicated that the "guru" of commodity models is Walter C. Labys at the University of West Virginia. Mr. Labys was contacted and he directed us towards his work *Primary Commodity Markets and Models: An International Bibliography*. Published in 1987, the book lists over 400 different commodity models. However, most were outdated or not applicable to Ontario.

Secondary Supply of Copper and Ferrous Metals and Canadian Metal Markets[9] [Centre for Resource Studies, Queen's University]

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

To predict the impact of scrap metal markets on the Canadian primary copper market.

1.2 Main Users

It is unknown whether is in current use.

1.3 Ownership

The model is owned by the Centre for Resource Studies.

1.4 Brief History of Development

The Centre for Resource Studies was established in 1973 to carry out research on mineral policy issues. Queen's University, the Department of Energy, Mines and Resources and the Mining Association of Canada sponsor the Centre.

This particular study was prepared by Kenneth R. Stollery, an associate professor at the University of Waterloo. The study looks at existing markets for copper and ferrous scrap metals, primarily in the U.S., and the effects of these markets on the demand and price of Canadian primary metal exports.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The study blends descriptive analysis and formal economic modelling in predicting the impact of scrap markets on Canadian primary markets. Described here is the econometric model employed by the author.

The copper market model framework is based on fundamental supply and demand theory. The model consists of equations estimating refined copper demand as well as the market supply of

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[9] Stollery, Kenneth R. (1983) "Secondary Supply of Copper and Ferrous Metals and Canadian Metal Markets" Kingston: Centre for Resource Studies, Queen's University, Technical Paper No. 3.

Contact: Margot Wojciechowski, Director, Centre for Resources Studies, Queen's University. (613) 545-2553

U.S. and Canadian primary refined copper, secondary refined supply, and new and old scrap in the U.S. The prices of refined copper and scrap copper are estimated based on exogenous variables such as general economic activity, demand for durable goods.

2.2 **Inputs/Estimation Period**

The exogenous variables of the model are:

- a durable goods index;
- a dummy variable for primary copper strikes;
- a dummy variable for 1972 supply disruptions;
- U.S. own price elasticity;
- labour rates;
- yield of U.S. primary metals industry; and
- a dummy variable for scrap export controls.

The period of estimation for the model is 1956-1979.

3.0 OUTPUTS

Economic Forecasts Provided by the Model

The model predicts the effects of scrap prices on Canadian primary exports, and the implications of energy price changes, primary metal grade decline, environmental controls, and other key factors for primary and secondary metal markets.

4.0 OTHER WORTHWHILE INFORMATION

None.

5.0 USEFULNESS

The model is useful in estimating the effect of policy issues on the primary copper and ferrous metals industries in Canada. However, the extent to which this model has been used is unknown. Additionally, the model has not been updated since its publication in 1983. In order to be an effective tool it might have to be updated.

Resource Strategies Inc.[10]

Resource Strategies Inc. (RSI) was established in 1984. It is a privately owned company that works entirely on a "fee for service" basis. Many of the principals in the firm were employed by Chase Econometrics, and RSI acquired Chase's Metals and Minerals Department in 1987.

In addition to running generic models for different industries, RSI prepares models for each client's specific needs. The underlying computer models are provided to the client in order that they may run alternative scenarios.

Resource Strategies Inc. runs various microeconomic models and relies on outside macroeconomic forecasts, such as those prepared by WEFA, to generate data for the industry specific models. Information on the underlying assumptions used to develop these models was not provided to Apogee. Rather, a forecasting model for the chrome industry was provided as an example of the work which RSI performs.[11] Therefore, the following description is based only on that model. It should be kept in mind that RSI offers many more modelling services than that described here.

1.0 GENERAL INFORMATION

1.1 Purpose of the Model

To evaluate the impact of economic, technical, managerial and policy scenarios on the chrome metal industry.

1.2 Main Users

A wide variety of private sector clients; government agencies.

1.3 Ownership

The model is the property of Resource Strategies Inc.

2.0 STRUCTURE OF THE MODEL

RSI models follow a hierarchial system. The sequence followed is:

- input of macro data;
- input of commodity data;

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10 Contact: Kenneth Hanby, Vice President, Resource Strategies Inc. (215) 269-6900.

11 Resource Strategies Inc. (October 1991) "Users Manual Model Documentation for RSI Chrome Computer Models" Exton, PA: RSI.

- input of supply/demand market models; and
- input of cost models.

The figure on the following page illustrates the structure and linkages between the different data blocks for the chrome model.

As the figure indicates, there are four major blocks in the model:

- the economic data module;
- the stainless steel market model;
- the chrome market clearing model; and
- the cost of production models.

2.1 Data Inputs

The macroeconomic information is broken into several categories: macroeconomic assumptions, global commodity prices, country macroeconomic data;

Sources for the macroeconomic assumptions include:

- Oxford Economic Forecasting;
- Haver Analytics;
- International Energy Agency;
- OECD Statistical Services;
- Maritime Strategies, Inc.; and
- United Nations' International Labour Office.

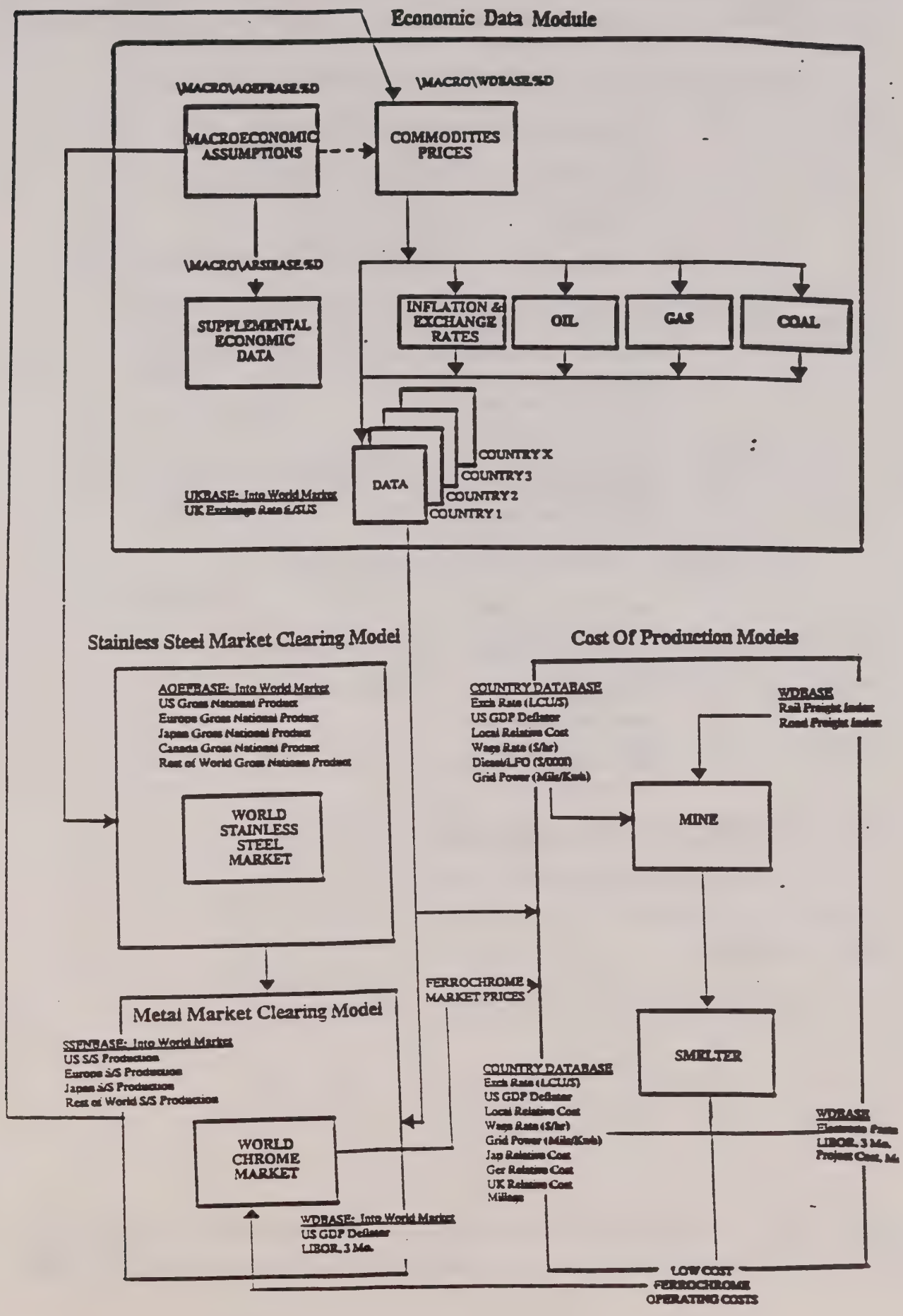
Commodity prices depend upon the following exogenous variables:

- metal prices;
- benchmark energy prices;
- transportation costs;
- labour costs;
- GDP deflators.

The country macroeconomic databases include the following variables.

- Grid Power;
- Local Relative Wage;
- Real Wage Inflation;
- Real Demand Cost;
- Metals Wage Factor;
- Local % of Supplies.

Linkages Between Economic Data Module and Metal Market Clearing Model



Country specific variables for inflation/exchange rate and energy variables include:

- Exchange variables, i.e. Japan relative cost
- Coal Variables - Steam Coal ($/GJ)
- Oil Variables - Industry HFO ($/t)
  Diesel/LFO ($/000 l)
- Gas Variables - Industry Gas ($/GJ)

Inputs for the Chrome Market Clearing Model are:

- international macroeconomic data;
- stainless steel production forecast;
- historical chrome data;
- historical ferrochrome data;
- mine capacity detail;
- ferrochrome capacity detail;
- East-West trade ferrochrome;
- East-West trade chromite.

The cost of production model incorporates the following inputs:

- commodities price data;
- country cost data;
- technical assumptions;
- carbon supply;
- ores supply;
- energy supply assumptions;
- efficiency adjustments;
- metal delivery assumptions;
- financial assumptions.

2.2 Time Period over which Forecasts are Made

Forecasts can vary, but are typically provided in the 5-10 year range.

3.0 OUTPUTS

Outputs from the chrome market clearing model are:

- price
- consumption
- supply
- operating rates
- market balance forecast.

Outputs from the cost of production model include:

- summary report of costs
- technical assumptions
- detailed list of assumptions
- side-by-side comparison of plants and/or scenarios.

4.0 OTHER WORTHWHILE INFORMATION

The model is IBM PC-compatible so alternative scenarios can be run by clients. This also allows for a validation of the assumptions employed by RSI. The system is also intended to be user friendly, requiring a minimum of input data to either update or create alternative scenarios.

4.1 Availability and Cost

Probe is a private firm offering a variety of services. The cost of tailoring this model for a specific client could vary widely depending on the particular needs of said client. A minimum estimate of $ 50,000 (US) was quoted by a company representative.

5.0 USEFULNESS

The forecasts prepared by RSI's market clearing models cover a wide range of issues. Within the market clearing models, the client, or user, has the ability to change the assumptions underlying the long-term forecasts. Therefore, different scenarios can be developed using the model.

Beyond this, it is not possible to assess the usefulness of the model based on the information provided.

RSI's goal is to allow companies to address competitive issues at the facility or firm level. The cost of production models are useful in addressing issues in the following five categories:

- physical properties of a site;
- macroeconomic policies and their impacts on the competitive position of facilities located in a specific country;
- management's policies toward productivity enhancing investments and contractual labour agreements; and
- the interplay between the factors which affect the demand and price for a facility's output.

Brook Hunt & Associates Limited[12]

1.0 BRIEF HISTORY AND GENERAL INFORMATION

Brook Hunt & Associates Limited was established in 1976 to provide independent research and consultancy services related to metal and mineral resources. Located in England, Brook Hunt offers services in the following metals: Aluminium; Copper; Lead; Nickel; and Zinc. Subscriptions to a quarterly report covering the period up to 2005 are available. The reports examine specific aspects of the industry, concentrating on consumption, competing materials, and the economics of substitution. In addition, the firm performs cost studies for individual operations, offers general consultancy in areas which include, mine planning, economic audits, studies on cost, competitiveness, and corporate planning.

The majority of Brook Hunt's forecasting is done through on-site market research, detailed, rather than with simply modelling the markets. Consumption analysis is based on detailed studies of end-use markets, which have been conducted over the last 10 years. Extensive econometric models are not employed in any area of their service. However, Brook Hunt owns and maintains an extensive database of industry information. The database contains production and cost data for over 1,500 operations and corporate data on approximately 2,000 firms. Based on this data, the firm has developed spreadsheet "flexing" models for each of the metals they analyze.[13] (The term "flexing" indicates that a user can input new values for parameters affecting production costs.) The models do not forecast estimated price levels, or consumption levels, but rather allow the flexing of metal prices and costs, from which it calculates new production costs.

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12 Contact: Terry Freezegreen, Brook Hunt & Associates Ltd. 011-44-932-568977

13 Brook Hunt & Associates (1991) "Zinc Mines Flexing Spreadsheet" company brochure.

9.0 Industrial Minerals

Despite a broad search, no forecasting models were identified for any industrial minerals including cement, sand and gravel, or gypsum. This information was derived from interviews with:

- *Industry, Science and Technology Canada*; .
- *Industry, Trade and Technology Canada*; and
- the Aggregate Producers' Association of Ontario.

Others contacted were in concurrence but added other useful comments:

- *Energy, Mines and Resources (Industrial Minerals)* stated that the only groups which might run industrial minerals models were those listed for metal mining. However, verification revealed that these companies do not, at present, run models of this nature.
- *CANDATA Southam Building Research* gathers and stores extensive data on the construction industry, a large user of industrial minerals. They do not run models, rather they use historical data and industry knowledge to forecast. Informetrica was noted as a company which might run models on products used in the construction industry.

A final check was made in "Primary Commodity Markets and Models: An International Bibliography". The publication revealed only one model for the cement industry, which was developed in 1964 for the Brazilian market.

10.0 Metal Casting

As with industrial minerals, no models were found for this industrial sector. The following information sources were contacted.

- *The Canadian Manufacturing Association* stated that any forecasting they do for any sector would be contracted to outside firms, or they would use data generated by companies such as WEFA, DRI, etc.

- *The Canadian Die Casters' Association* and the *Canadian Foundry Associations* stated that no models existed for the sector.

- *The American Foundrymens Society*, a technical group for the industry, performs the forecasts which are used by the U.S. Department of Commerce. However, they do not employ the use of economic models in preparing the forecasts. Rather, general economic data is combined with industry knowledge to create a forecast. The Society's representative stated that the industry is so diverse that over 1000 separate models would have to be developed to even come close to forecast accurately for the sector. Even if the models were to be developed he did not believe they would be any more accurate than judgemental analysis. The representative also stated that there are no models for the sector.

- *Industry, Trade and Technology Canada* did not know of any models specific to the metal casting industry.

11.0 Energy and Electric Power Generation

Two Basic Approaches

Most models of the energy sector adopt one of two basic approaches. Therefore, it is worthwhile to provide an overview of these approaches before examining individual models.

Approach 1 **Bottom-Up Models**

The bottom-up approach recognizes explicitly that the demand for energy is a *derived* demand; that is, the demand for energy results from the use of other goods and services. Energy requirements are assessed for highly detailed uses, such as the electrical requirements of Ontario's stock of microwave ovens or the demand in Manitoba for aviation turbo fuel from foreign airlines. As a general rule, bottom-up models exist for four categories of end-use: industrial, transportation, commercial and residential. Energy demand is aggregated up using simple summation.

This high level of disaggregation allows model users the freedom to estimate the effects of alternative technological options. "The key to the use of [bottom-up models] is the development of input data about the future -- a research task that requires analysts to keep abreast of developments that could impact on end use energy demand and to draw on outside expertise in making the many judgements that are required."[1]

Approach 2 **Top-Down Models**

The top-down approach predicts energy demand from historic trends of the relationships between energy demand and macroeconomic variables. Typically a measure of total energy demand is regressed upon macroeconomic variables. Forecasts for individual types of fuel are then determined by applying fuel shares to forecasts of total energy demand. Fuel shares are estimated by separate regressions of past fuel shares upon a wide variety of determinants specific to the fuel type.

This extrapolation of future demand from historic trends neglects the significant role changing technology plays in energy demand. The approach allows fewer options for modelling expected changes in energy efficiency, fuel alternatives, etc.

Energy Sector Modelling in Canada

The strategic economic importance of the energy sector to the Canadian economy is well recognized. Governments have long played a key role in managing certain segments of the industry. Aside from the regulation of provincial monopolies of electric utilities, policies such as the National Energy Policy clearly reveal the involvement of the government in the industry.

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1 Ontario Ministry of Energy (June 1979) "Energy Demand Models" Toronto: Ministry of Energy, p. 4.

Therefore, it is not surprising to find that governments play an active role in the modelling of the energy sector. Although a large number of energy sector models exist, the search focused upon those sources believed to be of most significance to the Ministry of the Environment. These included the following.

- *Ontario Hydro* employs a wide variety of forecasting models. They range from full-scale demand models to simple Box-Jenkins approaches.[2] Projections from these various models are combined in a somewhat subjective manner to produce one "Primary Load Forecast." The most significant of these models are discussed below.

- *The Ontario Ministry of Energy* has developed a full range of bottom-up (see below) models for four major end-uses: industrial, commercial, transportation and residential. In addition, a fifth model links the four end-use models to provide primary demands for each type of fuel. The Ministry also has access to Ontario Hydro's top-down econometric model (Econometric Energy Model of Ontario - EEMO).

- *Energy, Mines and Resources Canada* also houses a full range of models. Two traditional bottom-up models are maintained for the residential and transportation sector. An innovative "second-generation" end-use model is available for certain industrial sectors. Finally, a top-down model, the Inter Fuel Substitution Demand Model (ISFD), complements the bottom-up models.

- *Energy Resources Conservation Board*, an agency of the Albertan government, has developed for the Albertan economy a model which integrates a macroeconomic model, with an energy requirements model, energy price forecasting model and a greenhouse gas emissions forecasting model. All of these sub-models are for Alberta only.

In addition to these sources, a few further notes are worthwhile. First, the National Energy Board has traditionally been a significant modeller of the energy sector. A recent reorganization of the Board, however, has resulted in the migration of the Board's economic and modelling staff to Energy, Mines and Resources Canada. Currently the Board has no exclusive models.

Second, in light of its importance to the overall economy, many macroeconomic models have detailed energy sub-models. These are briefly reviewed elsewhere in the report. The MACE model is particularly noteworthy in this regard.

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[2] The Box-Jenkins method predicts variables which oscillate about a fixed mean. These oscillations result from shocks which impact upon the variable. The effect of the shock then follows a given pattern (for example, dies down exponentially). Box-Jenkins forecasts are suitable for the short-term. They are most heavily influenced by recent trends. For a detailed description, see Box and Jenkins (1976) *Time Series Analysis* San Francisco: Holden-Day.

Third, the client identified three particular models to be included in this inventory:

- MARKAL (MARKet ALlocation), used by a group in Montreal called GERAD;
- SERF (Socio-Economic Research Framework), maintained at the University of Waterloo; and
- the end-use models of Marbek Resource Consultants Ltd.

These three models are described in a separate section at the end of this chapter.

Energy Demand Models[3]
[Ontario Ministry of Energy]

1.0 GENERAL INFORMATION

1.1 Purpose of the Model

To forecast Ontario energy requirements by end-use and type of fuel, and to simulate the effects of changes in energy policy and other factors that influence energy demand.

1.2 Main Users

The Ontario Ministry of Energy.

1.3 Ownership

The Ministry.

1.4 Brief History

"Shortly after its formation, the Ministry of Energy identified a requirement for an energy model that would facilitate long-term energy demand forecasting and permit simulation of the effects of changes in policy and other factors that influence energy demand. In 1974, a review of existing models and of the state of the art was initiated. The conclusion that a new model would have to be designed specifically to meet the Ministry's requirements. In late 1975, studies were commissioned under the direction of a steering committee that included representatives from several provincial ministries and agencies. Three study reports were later published and in October 1977 the model was used for the first time by the Royal Commission on Electric Power Planning. Subsequently the model has been further refined and used in other applications" (Ontario Ministry of Energy, June 1979).

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The "model" comprises five bottom-up models. Four models forecast end-use demand by the residential, commercial, industrial and transportation sectors. A fifth model translates the sectoral (secondary) demand forecasts into primary energy demand forecasts. The difference between primary and secondary energy demand is that primary demand includes energy used by the energy distribution and processing sector to produce the energy required by end-user. For example, secondary energy demand from the residential sector includes the electricity and

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[3] Ontario Ministry of Energy (June 1979) "Energy Demand Models" Toronto: Ministry of Energy.

Contact: Rusty Chute, Energy Forecasts, Ontario Ministry of Energy. (416) 327-1402

fuels used by households. Primary energy demand from the residential sector includes the energy directly used by households, as well as the oil, coal, natural gas, etc. required to produce the electricity.

2.2 Estimation Period/Approach/Inputs

The basic inputs consist of the three data sets. Each data requirement is illustrated for the residential sector. Other sectors are comparable.

First, current and projected stocks of energy-using "devices" are required. These are generated using forecasts of sectoral activities. For example, the residential sector includes forecasts of the number of housing units of a particular age, fixed household equipment, such as air conditioners, and household appliances.

Second, for each type of energy-using device an energy consumption factor exists. These factors measure the amount of energy consumed per device. For example, energy consumption per television is included in the residential sub-model.

Third, for each energy-using activity, the model incorporates the share of each type of fuel used in that activity. This allows disaggregation of energy requirements into demand by fuel. For the residential sector, these relative penetrations of alternative fuels are available for natural gas, light fuel oil, electricity, wood, coal and direct solar.

Forecasts of all these variables are estimated using both econometric techniques and technological assessments. Additional variables are acquired from the Canadian macroeconomic model FOCUS (see below).

2.3 Time Period Over Which Forecasts Are Made

Forecasts are made for 20-25 year periods.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

The models generate energy demand by end-use and type of fuel. This can be done at a highly disaggregated level, for example, inter-city passenger travel by air.

3.2 Frequency of Forecasts

Variable, but usually every two years.

3.3 Capability to Forecast Outputs by Specific Facilities Within Specific Industry Groups in Ontario (i.e., Ontario applicability)

Production of each industrial sector is projected as an input to the energy demand forecasts. No breakdown by establishment is available.

5.0 USEFULNESS

5.1 As a Source for Macro/Commodity Forecasts

The model predicts energy demand for Ontario at a highly disaggregated level. In addition, forecasts of industrial production are used as inputs. The Ministry of Energy has developed econometric Industrial Output - Production equations that translate macroeconomic projections of dollar value of output (GDP) and other variables into physical output. This model covers six major energy-using industries - iron and steel, cement, industrial chemicals, pulp and paper, mining/milling and smelting, and automobile production.

Non-energy forecasts are not the focus of the model and, therefore, employ fairly simplistic methods. However, given the paucity of forecasting models in certain industrial sectors, this model may offer a last resort source. Further research is necessary to determine the accuracy of these projections.

5.2 For Forecasting Emissions, Effluents and Solid Wastes, and for Estimating the Impacts of Environmental Regulations

The Ministry of Energy has developed a simple, spreadsheet-based post-forecast model that translates forecasted energy use into emissions of CO_2, NO_x, SO_2 and VOCs. This model uses simple, average coefficients of emissions by energy type developed by EMR/Environment Canada. Emissions projections are for energy use only (final demand and implied electricity generation). Industrial process emissions are not modeled.

Ontario Hydro Forecasting[4]

1.0 GENERAL INFORMATION

1.1 Purpose of the Model

To forecast energy requirements in the province of Ontario.

1.2 Main Users

Ontario Hydro.

1.3 Ownership

Ontario Hydro.

1.4 Brief History of Development

Ontario Hydro has developed perhaps the most comprehensive set of energy demand forecasting models in Canada. These models span all the major modelling approaches, including both top-down econometric and bottom-up end-use. The Electric Power Research Institute (EPRI) has played an active role in developing many of the models. As in-house staff have undertaken refinements, trends in the model results have been revealed. Although different approaches continue to yield similar forecasts for residential and industrial demand, refinements have resulted in increasing gaps between commercial forecasts generated by different approaches.

2.0 STRUCTURE OF THE MODELS

2.1 Key Functional Relationships

Ontario Hydro employs numerous in-house models. We provide here a general overview of their modelling capabilities.

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[4] Ontario Hydro, Economics and Forecasts Division (December 1990) "Load Forecasts Report No. 901210" Toronto: Ontario Hydro.

Ontario Hydro, Economics and Forecasts Division (January 1991) "The 1990 Econometric Load Forecast" Toronto: Ontario Hydro.

Contact: Leslie Martel, Forecasting and Economics Department. (416) 592-6383

The major models of Ontario Hydro are three bottom-up end-use models and a top-down econometric model. These are supplemented with many other simpler models, such as those employing Box-Jenkins and single-equation regression techniques.[5] We present brief summaries of the four major Ontario Hydro models.

- **Residential End-Use Energy Planning System (REEPS)**

  REEPS is a bottom-up model of residential energy end-use. It employs the Residential Appliance Survey of 1988 to measure characteristics of Ontario households. Energy demand is then driven primarily by the number of single family households.

  Energy demand is calculated for space heating, space cooling, water heating, refrigerator, freezer, cooking, dishwasher, and "other" end uses. Forecasts incorporate the impact of Ontario government efficiency standards.

- **Commercial End-Use Energy Demand model (COMMEND)**

  COMMEND is similar to REEPS in that energy demand is calculated by projecting the stock of commercial buildings and their energy-consumption patterns. The building stock is estimated using regression analysis of the relationship between square footage and independent factors such as population, employment and GDP.

  End-uses modeled include space heating, air conditioning, lighting, ventilation, office equipment, miscellaneous equipment and non-building related demand.

- **Industrial End-Use Energy Demand model (INDEPTH)**

  Ontario Hydro's methods of modelling industrial demand are currently being substantially altered. Industry-specific models have recently been developed for four sectors: cement, petroleum refining, iron and steel, and pulp and paper. Work has begun on addition sectors.

  INDEPTH may be classified as a second-generation end-use model (see ISTUM model of Energy, Mines and Resources) in that competing production technologies are selected on the basis of cost minimization. Capital costs, operating costs and energy requirements are specified for each alternative technology, as well as financial variables such as discount rates.

[5] See the footnote above for a description of Box-Jenkins models.

- **Econometric Energy Model of Ontario (EEMO)**

  Ontario Hydro's top-down model estimates energy demand for the residential, industrial and commercial sectors. Each sector includes a number of equations which estimate sub-categories of energy demand.

  The basic specification for residential demand involves two regressions. The first estimates the "saturation" level of various energy-using appliances. The second estimates changes in energy requirements while holding appliance saturation constant.

  The commercial sector was modeled using two demand functions, one for electricity and the other for liquid fuels (oil and natural gas).

  Finally, the industrial sector is modeled using a cost function approach.

2.2 Estimation Period/Approach/Inputs

Required inputs vary according to the type of model.

2.3 Time Period Over Which Forecasts Are Made

Ontario Hydro produces both long-term (25-year) and short-term (5-year) forecasts.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

Ontario Hydro produces four types of demand forecasts. Long-term and short-term projections are made for both the "Basic Load Forecast" and the "Primary Load Forecast." These are defined as follows:

- Basic Load Forecasts: demand projected from all variables which the utility views as exogenous, including macroeconomic variables, sectoral economic growth, demographic variables and government regulations (such as the Ontario Energy Efficiency Act and the Ontario Building Code);

- Primary Load Forecasts: Basic Load Forecasts net of Ontario Hydro demand management programs, including energy audits, conservation incentives, load shifting programs (away from peak hours) and load displacement non-utility generation programs (to encourage customers to produce their own electricity where possible).

The Primary Load Forecast is viewed as the most likely projection of load (demand) that Ontario Hydro must plan to supply. In 1990, it was about 10% lower than Basic Load Forecast.

3.2 Frequency of Forecasts

Major forecasts are up-dated annually.

4.0 OTHER WORTHWHILE INFORMATION

None.

5.0 USEFULNESS

5.1 As a Source for Macro/Commodity Forecasts

Due to its degree of regulation, Ontario Hydro's forecasting methods have been the focus of much public scrutiny. Pressure from various public commissions into Ontario Hydro forecasts may have increased the accuracy of Ontario Hydro models relative to other models. Further efforts would be required to verify this. In addition, it is unknown whether the utility would undertake special forecasting requests from the Ministry.

Transportation Energy Demand Model and Residential End-Use Model[6]

[Energy, Mines and Resources]

1.0 GENERAL INFORMATION

1.1 Purpose of the Model

To predict energy end-use at highly disaggregated levels.

1.2 Main Users

Energy, Mines and Resources.

1.3 Ownership

Efficiency and Alternative Energy Technology Branch, Energy, Mines and Resources.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The two models adopt typical bottom-up end-use approaches. The core of the models are: (i) measures of energy-using activities and devices; and (ii) variables describing the energy requirements of these activities and devices. These components are combined using accounting identities. Energy demanded by each end-use is summed to create aggregate energy demand.

2.2 Inputs

The models require measures of energy-using activities and devices. For example, the housing stock, proxied by the number of households, and the vehicle stock serve as the basic measures of end-use activities for the residential and road transportation activities. Demand for these stock variables are derived from external forecasts which incorporate economic factors, such as income and costs.

Coupled with these are descriptive variables such as number of houses with particular forms of heating methods and the energy requirements of each method.

2.3 Time Period Over Which Forecasts Are Made

Currently energy requirement forecasts are made on an ad hoc basis. Forecasts can be made for as far ahead as input forecasts are available. End-use can be predicted under various scenarios regarding energy efficiency, fuel substitution, growth in housing stock or

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6 Contact: Jean Pierre Moisan, Energy Efficiency Analysis, Energy, Mines and Resources. (613) 995-7491

transportation activities, etc. For example, current work on Vision 2020 will generate forecasts until the year 2020.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

The Residential End-Use Model (REUM) disaggregates residential end-use into the following categories:

- Geographical: Canada, Atlantic, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, B.C. (including territories)
- Fuels: electricity, natural gas, oil, wood, coal, propane
- End-Use: space heating, appliances, water heating, space cooling (each end-use is further disaggregated into many sub-categories)

The Transportation Energy Demand Model (TEDM) disaggregates transportation end-use into the following categories:

- Geographical: Canada, Atlantic, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, B.C. (including territories)
- Fuels: motor gasoline, natural gas, light fuel oil and kerosene, heavy fuel oil, diesel, aviation jet kerosene, aviation jet naphtha type, aviation gasoline, coal, electricity, propane, gasohol (including others)
- End-Use: air, rail, marine, road (cars, trucks)

3.2 Frequency of Forecasts

Forecasts are made on a project-by-project basis.

3.3 Capability to Forecast Outputs by Specific Facilities Within Specific Industry Groups in Ontario (i.e., Ontario applicability)

Average household or average vehicle.

4.0 OTHER WORTHWHILE INFORMATION

The REUM and TEDM are written in SIMSYS programming language and utilizes Mosaic Data Management Software.

Both REUM and TEDM are being revised to include further disaggregation. For example, road transportation end-use is being disaggregated by vehicle characteristic.

5.0 USEFULNESS

5.1 As a Source for Energy Demand Forecasts

The models are able to project energy use in Ontario in similar ways as other end-use models housed in Ontario Hydro and the Ontario Ministry of Energy. The TEDM does not contain as detailed disaggregation as other models. Further research is necessary to obtain details of their differences.

5.2 For Forecasting Emissions, Effluents and Solid Wastes, and for Estimating the Impacts of Environmental Regulations

The TEDM is one of the few models of any sector which currently encompasses an embedded emissions forecasting model. Environment Canada's MOBIL 4 model is the source of emission factors which are multiplied by transportation activities to project emissions of CO_2, NO_x, VOC and CH_4.

Industrial Sector Technology Use Model[7]

[Energy, Mines and Resources Canada]

1.0 GENERAL INFORMATION

1.1 Purpose of the Model

To forecast energy demand of the industrial sector.

1.2 Main Users

Energy, Mines and Resources.

1.3 Ownership

Unknown.

1.4 Brief History of Development

The ISTUM was first developed in 1978 for the U.S. Department of Energy. In 1987 a partially completed PC version of the model was finished by M. Jaccard of Simon Fraser University. A successful application was made to the B.C. pulp and paper industry in 1988. Since then the model has been extended to include other sectors and provinces (see outputs).

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The ISTUM has been dubbed a "second-generation" end-use model. First-generation models include the TEDM and REUM and the end-use models of Ontario Hydro and the Ontario Ministry of Energy. In these models, technical coefficients measuring energy requirements per unit of economic activity are determined exogenously. Forecasting energy use requires exogenously forecasting trends of these coefficients.

In contrast, the ISTUM determines these technical coefficients endogenously. The ISTUM explicitly incorporates the investment decision of producers in energy forecasts. For example, an application to B.C.'s pulp and paper industry allowed producers to choose between over 50 types of technology on the basis of cost-minimization. Decisions regarding equipment retirement and new investment are endogenous to the model, technology selection being made on the basis of lowest annualized life cycle cost. In this way, the evolution of the industry's

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[7] Jaccard, M. and J. Roop (1990) "The ISTUM-PC Model: Trial Application to the British Columbia Pulp and Paper Industry" Energy Economics (July):185-212.

Contact: Jean Pierre Moisan, Energy Efficiency Analysis, Energy, Mines and Resources. (613) 995-7491

capital stock, and its energy requirements, is determined by the model rather than imposed in the form of fixed energy consumption coefficients.

2.2 Inputs/Sources/Approach

The model is calibrated using many data inputs, including:

- evolution of equipment stocks (Post's and Lockwood's pulp and paper industry directories for 1977, 1982 and 1987);
- equipment costs (U.S. Department of Energy);
- energy balances of Canadian plants (Canadian Pulp and Paper Association);
- energy prices (B.C. Hydro); and
- discount rates and accounting practices (survey of literature on average payback periods used by industry decision-makers).

Since the model is not calibrated using econometric methods, historical time series are not required for many variables.

In addition, forecasting energy demand from an industry requires projections of energy prices and demand for that industry's output.

2.3 Time Period Over Which Forecasts Are Made

The model is used for long-term forecasting (for example, 20 years).

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

The model computes energy demand by type of fuel for a particular industry. For example, an application to B.C.'s pulp and paper industry forecasted demand for fuel oil, natural gas, electricity and hog fuel.

To date, the model has been calibrated to forecast energy demanded by the following sectors and provinces:

- Pulp and Paper (B.C.)
- Iron and Steel (Quebec, Ontario)
- Cement (Quebec, Ontario, B.C.)
- Aluminum (Quebec, B.C.)
- Petroleum Refining (Ontario, Alberta)

3.2 Frequency of Forecasts

The model is being used on an ad hoc basis. No regular forecasting schedule has been established.

3.3 Capability to Forecast Outputs by Specific Facilities Within Specific Industry Groups in Ontario (i.e., Ontario applicability)

The model has been used to forecast only energy demand from entire industries.

4.0 OTHER WORTHWHILE INFORMATION

When calibrating the model to an individual sector and province, the following regional- and sectoral-specific data are required, including: equipment stocks, equipment prices, final demand for the sector's output and energy prices.

5.0 USEFULNESS

5.1 As a Source for Macro/Commodity Forecasts

The model is capable of forecasting energy demand for three Ontario industries: iron and steel, cement and petroleum refining. The model's strength is its ability to incorporate changing production technology. Since little technological change occurs in the short-term, the model is especially suited to long-term forecasts.

5.2 For Forecasting Emissions, Effluents and Solid Wastes, and for Estimating the Impacts of Environmental Regulations

The Model does not forecast emissions. However, since the model is rich in technological detail, it may be appropriate for studying the impact of environmental regulations which alter production technology.

Inter-Fuel Substitution Demand Model[8] [Energy, Mines and Resources Canada]

1.0 GENERAL INFORMATION

1.1 Purpose of the Model

To forecast energy demand and simulate the effects of public policy on energy demand.

1.2 Main Users

Policy analysts in the public and private sectors.

1.3 Ownership

Energy, Mines and Resources.

1.4 Brief History of Development

The model developed in the mid-1970s by Energy, Mines and Resources.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The model relies on an econometric approach that relates aggregate energy consumption to a variety of variables that influence energy demand. These include relative prices, economic growth and demographic trends. However, the model is not completely based on historical evidence as it reflects some future-oriented variables, such as announced plans of electrical utilities and changes in the structure of the auto market.

The model is disaggregated into five sectors: residential, commercial, industrial, transportation and non-energy. For the first three sectors, historical demand, in terms of output joules, is obtained by multiplying the amount of energy input by the efficiency of conversion processes. Output joules are then forecast for each period as a function of past demand, heating degree days, an energy price index and economic and demographic variables. The economic variables included in each sector are:

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8 Information presented here is taken from "Forecasting Canadian Energy Demand and CO_2 Emissions: The EMR/EC Reference Case" A report by Energy and Fiscal Analysis Division, Economic and Financial Analysis Branch, Energy, Mines and Resources Canada, September, 1990.

Contact: Michel Bérubé, Energy and Fiscal Analysis Division, Energy, Mines and Resources. (613) 996-7337

- residential sector: number of households and personal disposable income per household;
- commercial sector: real domestic product; and
- industrial sector: industrial GDP and capital stock.

The resulting forecasts of output joules are then disaggregated into three major fuel types: natural gas, electricity and oil distillates (light fuel oil and kerosene in the residential sector and heavy fuel oil in the commercial and industrial sectors). This disaggregation is accomplished by estimating fuel market shares as functions of relative prices, heating degree days and non-price variables. This allows inter-fuel substitution to be estimated taking into account projected changes in relative fuel costs. Output joules are then divided by end-use efficiencies to obtain fuels actually purchased.

Recently, EMR has expanded its industrial model so that it now features at the provincial level a breakdown of energy consumption by major industries. The industries are: pulp and paper, iron and steel, chemical, smelting and refining, other manufacturing, mining, forestry and construction.

For the transportation sector, energy demand forecasts are made on a more disaggregated basis. Demand for motor gasoline is based on a projection of average efficiencies, average distance travelled per mile and the passenger vehicle stock. Demand for diesel fuel oil is projected as a function of the price of diesel fuel, industrial economic growth and projected growth in the commercial sector vehicle stock. Demand in rail, marine and aviation sub-sectors reflect expected economic growth and the cost of fuels.

The non-energy sector comprises energy demand used to produce petrochemicals, asphalt, lubes, greases and naphtha specialities. These are either estimated as functions of economic variables and prices or are based on the production plans of the petrochemical sector.

2.2 Estimation Period/Approach/Inputs

The model is estimated using data from 1962 to 1988. Projections of independent economic variables are obtained from Informetrica.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

The final product of the model is fuels purchased by sector and type of fuel.

3.2 Frequency of Forecasts

Regular forecasts are up-dated every two years.

3.3 Time Period Over Which Forecasts Are Made

The model is primarily for long-term forecasting. Forecasts are made up to 2020.

3.4 Capability to Forecast Outputs by Specific Facilities Within Specific Industry Groups in Ontario (i.e., Ontario applicability)

The model is disaggregated into 7 regions: Atlantic, Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia. Equations are estimated separately for each region. regional forecasts are then summed to produce national forecasts. Therefore, the model forecasts explicitly energy demand by sector in Ontario. The model does not produce forecasts for individual production facilities.

4.0 OTHER WORTHWHILE INFORMATION

None.

5.0 USEFULNESS

5.1 As a Source for Macro/Commodity Forecasts

The model is useful for forecasting energy demand by fuel type, by province and by some specific economic sectors.

5.2 For Forecasting Emissions, Effluents and Solid Wastes, and for Estimating the Impacts of Environmental Regulations

An emissions satellite model forecasts emissions of CO_2, SO_2, NO_x, VOCs and CH_4.

Integrated Model of Alberta[9]

[Energy Resources Conservation Board]

1.0 GENERAL INFORMATION

1.1 Purpose of the Model

To capture the interrelationships between energy prices, economic activity and energy demand; and to identify emissions resulting from production and consumption of energy..

1.2 Main Users

The Government of Alberta.

1.3 Ownership

The ERCB is the proprietor of the model.

1.4 Brief History of Development

Alberta's Energy Resources Conservation Act of 1971 required "the appraisal of energy requirements for energy resources and energy in Alberta." Therefore, the Board conducted long-term energy demand forecasts every three to four years. In 1988, the ERCB increased its modelling activities to generate annual forecasts. Construction of the model was begun for this purpose. The model has yet to be fully completed.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The Integrated Model of Alberta (IMA) is composed of four linked models: the Macroeconomic Model of Alberta (MEMA), the Energy Price Forecast Model (ENEPRICE), the Energy Requirements Model of Alberta (ERMA) and the Greenhouse Gases Emissions Model of Alberta (GREEN). The IMA consists of over 1500 endogenous and identity equations. Many estimation methods are used, including econometrics, engineering, accounting, market information and consultation with industry and government.

The MEMA is a relatively small macroeconomic model. In recognition of the driving role played by the mining sector in the Albertan economy, coal, conventional oil and gas, oil and oil

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9 See Energy Resources Conservation Board (July 1990) "A Summary of the Structure of the Integrated Model of Alberta (IMA)" Calgary: ERCB.

Contact: Dr. Abbas Naini, Market Forecasting and Environmental Studies, Energy Resources Conservation Board. (403) 297-3540

sands, as well as metal mines, non-metal mines and quarries, are modeled separately. This sector is the major driving force behind the aggregate macroeconomic variables for Alberta.

The ERMA is a collection of sub-models which generate energy demand using a bottom-up approach. Although not as disaggregated as the models of the Ontario Ministry of Energy, much industry detail is generated. Different approaches are used for different sectors. For example, demand for gas and electricity are estimated using an accounting framework. Energy consumption factors per end-use are applied to forecasts of energy-consuming activities. On the other hand, demand for motor fuels is projected using a regression of fuel demand upon independent variables such as average kilometres travelled per vehicle and fuel efficiency.

The Greenhouse Gas Emissions Model operates on an accounting framework. Emissions coefficients form a matrix which, applied to a matrix of economic activity, yields total emissions of VOCs, methane, carbon dioxide and nitrogen oxides.

2.2 Estimation Period/Approach/Inputs

The models incorporate data from many sources, including Statistics Canada and the Albertan government. Projections of Canadian macroeconomic variables, such unemployment, inflation and interest rates, are obtained from the WEFA Canadian Long-Term Economic Forecast Service. A wide variety of studies conducted outside Alberta provide emissions coefficients.

2.3 Time Period Over Which Forecasts Are Made

The model can generate 15-year forecasts.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

In addition to details of the energy sector and energy demand from all economic activities, the model encompasses Alberta's macroeconomy. Therefore, the outputs of the model are numerous, ranging from Alberta's aggregate GDP to energy demand by fuel and end-use. Perhaps of most interest to the Ministry is the emissions model which generates greenhouse gas emissions by sector.

3.2 Frequency of Forecasts

Unknown.

3.3 Capability to Forecast Outputs by Specific Facilities Within Specific Industry Groups in Ontario (i.e., Ontario applicability)

The model is for the Albertan economy only.

4.0 OTHER WORTHWHILE INFORMATION

None.

5.0 USEFULNESS

5.1 As a Source for Macro/Commodity Forecasts

The model forecasts are strictly for the Albertan economy. Although the model is interesting from a theoretical perspective, it does not appear to be directly applicable to the Ontario economy.

5.2 For Forecasting Emissions, Effluents and Solid Wastes, and for Estimating the Impacts of Environmental Regulations

The model has made a large step in developing an emissions model. These matrices of emissions coefficients may be applicable to the Ontario economy. Indeed, some coefficients were taken from Ontario-specific studies.

6.0 Three Other Energy Models

1. MARKAL[10]

MARKAL stands for MARKet ALlocation. It is described by its operators as follows:

MARKAL is an integrated multi-period linear programming model of energy systems, characterized by the representation of individual devices and energy carriers at every stage of the extraction, transformation, distribution, and consumption of energy forms. The model is driven by useful demands for goods and services in the economic subsectors.

MARKAL was developed initially in the late 1970's through the efforts of the International Energy Agency. The Canadian version of MARKAL was developed in several stages over the period 1984-1989 to meet specific applications. The Canadian model is run by a group named GERAD (Groupe d'études et de recherche en analyse des décisions) at McGill University.

Specific applications of MARKAL to Ontario's mineral processing industries and to acid gas emissions in Québec are referenced in the bibliography. The following description of the Canadian MARKAL model is taken from GERAD's most recent publication.

MARKAL is a multiperiod linear programming model of a region or country. It is a demand driven model in which a solution must satisfy the exogenously specified set of end-use demands at all time periods. These demands are given in terms of different socio-economic needs, such as industrial end products, residential space heat, personal transportation, etc. A number of end-use devices can compete to satisfy a particular demand, and a number of production technologies can compete to produce the same energy form.

Technologies are represented explicitly in the model in terms of their technical and economic characteristics. This feature allows the model to be readily applied to technology assessment.

Within MARKAL, the energy system is divided into four technology classes: SRC (energy sources), PRC (transformation processes), CON (energy conversion into electricity and/or low-temperature heat) and DMD (demand technologies). On the supply side, primary energy is made available to the system by extraction technologies such as coal mining, oil and gas production, or biomass conversion. Both primary energy forms and refined products may be imported or exported. Fuels can be used for electricity generation or transformed into other fuel types in process technologies such as oil refineries and coal liquefaction. Finally, energy is consumed in the system by a set of competing demand technologies.

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[10] Contact: Jean-Philippe Wauub, École des Hautes Études Commerciales. (514) 340-6053

Electricity generation and process technologies are modeled in MARKAL by three variables representing investment, capacity, and production (also called activity). For a given production capacity, actual production is bounded by capacity and an annual availability factor. For demand technologies, the activity is assumed to be strictly proportional to the capacity, thus requiring only an investment variable and a capacity variable to model such technologies.

A feature of MARKAL is the availability of a variety of objective functions which can be used either individually or in combination in trade-off analyses. The most frequently used are system-discounted cost, cumulative oil imports, and renewable energy.

When driven by the minimum system-discounted cost-objective function, the model chooses that mix of mined or imported fuels and electricity-generating, process, and demand technologies which minimizes the total discounted cost of installing and operating all technologies over the optimization period. No account is taken of the investment costs already sunk in the system which existed at the start of the optimization period. However, the model does acknowledge the existence of initial installed capacities of technologies at the start of the first period. Each such technology is carefully described by a schedule of residual capacities at subsequent periods, until complete extinction of the initial capacity. Similarly, to each new investment is attached a life duration.

The Canadian version of MARKAL represents a significantly improved model as compared to the already powerful standard one. The new version permits the modelling of energy and material flows, in a completely regionalized energy system. The electricity exchanges between regions are more accurately and conveniently represented, as well as the inter-seasonal reservoir management, which is an important characteristic of real life hydro systems. The Canadian model also allows the construction, within MARKAL of complex oil refining modules with many inter-related technologies, and intermediate products, and the inclusion of the all important blending constraints which specify quality requirements for refined petroleum products. Modelling environmental emission constraints is now possible, and the reporting of environmental primal and dual values is more complete in our version. Finally, a minor but useful alteration constraints allows the modelling of some important constraints representing retrofitting and life extension of some industrial processes.

These improvements of the MARKAL features have all been motivated by actual applications made by GERAD researchers for various applied research projects. As a consequence, they have been thoroughly tested and validated, and are now available either in a mainframe or in a micro-computer implementation.[11]

[11] Berger, C., Bubois, R., et al. *Canadian MARKAL: An advanced Linear Programming System for Energy and Environmental Modelling.* GERAD Université McGill, April 1991.

2. SERF[12]

SERF stands for *Socio-Economic Research Framework*. It represents an approach to socio-economic modelling, developed by a group of researchers who used to be at the Structural Analysis Division of Statistics Canada. Two of the instigators have since left Statistics Canada and have formed a company called *Robbert Associates- Decision Support Tools* that is refining and expanding the ideas.

This work is based on what the authors call the "design" approach to socio-economic modelling. The theory of this approach is that the models, the simulation framework and the user combine to produce a way of exploring the future rather than predicting it. The user explores alternative futures, learns through repeated simulations and introduces change and novelty through new scenarios.

References to the original SERF work are provided in *The Design Approach To Socio-Economic Modelling*[13] and *The Evolution of Socio-Economic Modelling in Canada*.[14]

The company Robbert Associates has since refined this work and has developed *CEEF*, standing for *Canadian Environment Economy Simulation Framework*. The objective of CEEF is to represent the linkages between human populations and the natural resource base and to provide a framework for exploring alternative evolution paths. CEEF represents the dynamic interactions among the fifty main physical transformation processes that constitute the Canadian socio-economy in the context of its natural resource base. CEEF is neither predictive nor prescriptive: rather, it is sold explicitly as an "open simulation framework intended to explore the evolution paths that result from alternative patterns of societal choices".

A set of slides summarizing the objectives and workings of the CEEF model are provided in Appendix D.

Neither the SERF nor CEEF models and development languages are likely to be of interest to the MOE from the perspective of this study.

3. Marbek Resource models[15]

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12 Contact: Robert Hoffman, Robbert Associates. (613) 232-5613

13 Gault, F.D., Hamilton, K.E., et al. *The Design Approach to Socio-Economic Modelling* Futures. February 1987.

14 Hoffman, R.B., and McInnis, B.C. *The Evolution of Socio-Economic Modelling in Canada* Elsevier Science Publishing Co., Inc. 1988

15 Contact: Marbek Resource Consultants, Ottawa, Ontario, (613) 523-0784

Marbek Resource Consultants Ltd. also has developed its own Household Energy Efficiency Target model, known as HEET. Marbek describes it in the following way.

The HEET model is a Lotus-based end-use energy accounting model. It consists of several modules which calculate residential sector baseline and conservation scenario energy requirements based on many inputs, for both existing and new dwelling stock. Three major end uses are included in the model: household appliances, space heating and cooling, and domestic water heating.

HEET incorporates a "bottom-up" disaggregated approach to energy efficiency analysis which focuses on a detailed characterisation of each energy end-use. At this level, each end-use is characterized in terms of its energy intensity, fuel share, and technology share (ie the share allocation of technology generations which contribute to the estimated energy intensity).

The model is employed primarily to calculate technical and economic potentials for energy efficiency and/or fuel substitution. These potentials are calculated against a baseline projection known as the frozen-efficiency forecast. As an accounting model, HEET is reliant upon externally specified demographic and economic statistics (eg dwelling stock or population growth and GDP growth) to establish target year baseline consumptions.

The model has been used by government and utility clients coast-to-coast in Canada.

12.0 Recreation and Tourism

Introduction

Various levels of government are heavily involved with tourist and recreational activities. Many public agencies directly provide park, beach, waterway, and sports infrastructure, while others operate funding programs for such initiatives. Furthermore, government agencies undertake much of the marketing and promotional activities for the sector. For these reasons, government ministries have been quite active in developing models of the tourism and recreation sector. Since the private element of the sector consists largely of small, independent agents with few resources to undertake formal economic analysis, few private forecasting models exist.

Government branches involved with tourism and recreation generally undertake two types of economic modelling. First, demand forecasting is conducted in the form of variables such as park attendance and recreational participation rates. Second, governments often maintain formal models of the economic impact of these activities.[16] These latter models are beyond the mandate of this study and hence have been omitted from the following discussion.

Before turning to individual models, it is useful to outline the major sources of models that were examined.

- *The Ontario Ministry of Tourism and Recreation* houses two major models. The Interactive Model of Recreational Activity is discussed fully below. A recently-developed econometric model of tourist demand in Ontario is still classified as confidential and hence is only briefly mentioned.

- *The Ontario Ministry of Natural Resources* includes two branches of interest. First, the Office of Recreational Boating was investigated. Although the number and value of recreational boats are often forecasted, the Office does not use formal models. Rather surveys are conducted of the current situation and growth rates are derived from estimates provided by private companies. The second branch contacted was the Provincial Parks and Recreational Areas Branch. Demand forecasts are not undertaken for Ontario provincial parks and recreational areas.

- *The Ontario Ministry of the Environment* commissioned several demand forecasting models for the tourist and recreational activities. These are unique in that they incorporate environmental quality as a determinant of demand.

- *Canadian Parks Service*, located within Environment Canada, undertakes demand forecasts for national parks' services. Although each forecast employs different models, the agency's general methodology is discussed.

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16 See, for example, Ontario Ministry of Tourism and Recreation (August 1988) "Economic Impact of Tourism in Ontario - 1985" Toronto: Ontario MTR.

- *Tourism Canada*, located within Industry, Science and Trade Canada, has in the past housed formal forecasting models.[17] However, the agency deemed them too simplistic and ceased in-house modelling efforts. Currently all modelling for Tourism Canada is conducted by the Canadian Tourist Research Institute. Their services are outlined below.

- In addition to the Canadian Research Tourist Research Institute, one other non-government model was discovered. An outdoor recreation forecasting model developed by demographic economist, David Foot, is also discussed.

[17] For example, see the Box-Jenkin model described in "Methodology for Short Term Forecasts of Tourism Flows" Research Report No. 4, Economic Research Section, Office of Tourism, January 1977.

Interactive Model of Recreational Activities[18]

[Ontario Ministry of Tourism and Recreation]

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

The model is used for forecasting the levels of various recreational activities using demographic trends and fixed participation rates.

1.2 Main Users

The Ontario Ministry of Tourism and Recreation is the only primary user.

1.3 Ownership

The model is maintained in-house at the Ministry.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The foundation of the model is the fundamental identity:

$$N_i = (N_i/P)*P = PR_i*P$$

where N_i = number of participants in activity i,
P = total population,
PR_i = participation rate in activity i.

In order to account for changes in recreational activity by age, the equation is disaggregated by age group:

$$N_i = \Sigma(N_{ij}/P_j)*P_j = PR_{ij}*P_j$$

where N_{ij} = number of participants of age category j in activity i,
P_j = total population in age category j,
PR_{ij} = participation rate of age category j in activity i.

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18 See Chang, Aria (1990) "Users' Manual: Interactive Model of Recreational Activity Using Demographic Data," mimeo, Ministry of Tourism and Recreation, Toronto.

Contact: Marj Keast, Recreation Policy Branch, Ontario Ministry of Tourism and Recreation. (416) 965-5665

These formulae are used to project recreational demand by holding participation rates constant and feeding in population projections by age category. Since population projections are available for individual counties, projections can be made at highly disaggregated levels.

2.2 Estimated Period/Inputs

The model has two primary data sources. The Outdoor Leisure and Activity Planning Study (OLAPS) conducted by the Ministry in the Fall, 1989 provides participation rates by age category. The Ontario Ministry of Treasury and Economics provides population projections.

2.3 Time Period over which Forecasts are Made

Since participation rates are held constant, the only limitation to projecting recreational activities is the availability of population forecasts. Currently forecasts can be made on an annual basis to 2011.

3.0 OUTPUTS

3.1 Activity Forecasts

The model provides annual forecasts of a wide variety of recreational activities. Forecasts may be disaggregated to individual counties.

4.0 OTHER WORTHWHILE INFORMATION

The model can be run on any IBM-compatible personal computer with 640K RAM. The model is essentially two matrices stored as LOTUS 123 spreadsheets and run using the Lotus macro capabilities.

5.0 USEFULNESS

5.1 As a Source for Activity Forecasts

The model's approach is commonly used for demographic-based demand forecasts. Some analysts severely criticize the approach for lack of sophistication. In particular, the assumption of constant participation rates derived from cross-sectional surveys, coupled with population forecasts, may not be very accurate for long-term forecasting. Ideally, one would wish to account for trends in age-specific participation rates. Furthermore, an inconsistency is embedded within the model. Since forecasts are driven by slow-changing demographic data, the model's structure is more suited to long-run forecasting. However, the assumption of constant participation rates becomes less realistic as simulation periods are lengthened. This inconsistency casts doubt upon the accuracy of the model's results.

Ontario Forecasting Model of Tourism Demand[19] [Ontario Ministry of Tourism and Recreation]

1.0 GENERAL INFORMATION

1.1 Purpose of the Model

To provide annual forecasts of tourist traffic flows in terms of both number of person-trips and expenditures for a variety of categories of tourists.

To provide annual estimates over a short (up to two years) and medium (three to five years) time horizon.

To provide annual estimates of the receipts on travel account between Ontario and the U.S. and other countries.

1.2 Main Users

The Ontario Ministry of Tourism and Recreation.

1.3 Ownership

The model is maintained in-house at the Ministry.

1.4 Brief History of Development

The Ministry developed an econometric forecasting model in 1978 to forecast for short, medium and long-term time horizons. The model was allowed to lapse and a speculative forecasting technique, "Jury of Executive Opinion," was instituted. Long-term forecasts using this method were deemed to unreliable. Consequently, a supplementary forecasting model was constructed.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The model contains 19 equations that can be divided into three general sections.

- Person-trips: a separate equation exists for each of the six output categories described below. Depending on the equation, the following types of explanatory variables were used: real personal disposable income; corporate

[19] Information is taken directly from "The Ontario Forecasting Model of Tourism Demand."

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profits; exchange rates; relative price levels; and dummy variables for events such as the Olympic games and bicentennial celebrations.

- Tourist Expenditures: a separate equation exists for expenditures of each type of person trip described below. Explanatory variables are: lagged expenditures; changes in relative prices; and changes in person-trips.

- Linking Identities: these include summing over categories of person-trips and expenditures and calculating net travel balances between Ontario and other jurisdictions.

2.2 Estimation Period/Approach/Inputs

The Ministry houses historical time series on person-trips and expenditures. Canadian and U.S. historical data on explanatory variables were obtained from the Conference Board of Canada. In addition, a provincial trave price index was developed by the Canadian Tourism Research Institute. Foreign, excluding the U.S., explanatory data were obtained from the OECD, Bank of Canada and IMF. Finally, the Conference Board's medium-term national and provincial forecasts of explanatory variables were used to forecast the dependent variables.

Data are annual due to poor availability of quarterly data.

Each stochastic equation was estimated independently using ordinary least squares regression techniques.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

The model forecasts person-trips and expenditures over a short and medium-term horizon. The model disaggregates traffic flows for the following categories:

- Ontario residents travelling within Ontario;
- American visitors to Ontario;
- Other Canadian visitors to Ontario;
- Other country (excluding U.S.) visitors to Ontario;
- Ontario residents' visits to the U.S.; and
- Ontario residents' to other countries (excluding the U.S.).

Receipts on travel account are disaggregated by Ontario, the United States and other countries.

3.2 Frequency of Forecasts

Unknown.

3.3 Time Period Over Which Forecasts Are Made

Forecasts are made for the short term (2-3 years) and the medium-term (3-5 years).

3.4 Capability to Forecast Outputs by Specific Facilities Within Specific Industry Groups in Ontario (i.e., Ontario applicability)

Not applicable.

4.0 OTHER WORTHWHILE INFORMATION

The model was developed using TROLL software and then transferred to LOTUS worksheets. Operations from LOTUS include: initiating the model, reproducing regressions, preparing baseline and alternative forecasts, updating historical data and retrieving mnemonic descriptions. A user manual is available.

5.0 USEFULNESS

5.1 As a Source for Macro/Commodity Forecasts

As described above, the model forecasts person-trips and tourist expenditures.

5.2 For Forecasting Emissions, Effluents and Solid Wastes, and for Estimating the Impacts of Environmental Regulations

No environmental variables appear in the model.

Model of Beach Use and Environmental Quality[20]

[Ontario Ministry of the Environment]

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

To forecast the consequences of pollution abatement and environmental protection programs in terms of changes in beach use and enjoyment.

1.2 Main Users

It is unknown to what extent the model is currently being used, either by the Ontario Ministry of the Environment or otherwise.

1.3 Ownership

The model is maintained in-house at the Ministry.

1.4 Brief History of Development

The Ministry commissioned a consulting team led by Anthony Usher Planning Consultant to develop the model. The model was completed in May 1987.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The model is of an origin-constrained gravity format. The flows of beach users from each of 8 geographical origins to each of 555 beach destinations are estimated. These flows depend upon population demographics, swimming participation rates, and beach attractiveness. An attractiveness index incorporates beach characteristics such as administration, size, water temperature, ease of access, aesthetics and environmental quality.

2.2 Data Inputs (Source)

- Population Projections (Ontario Ministry of Treasury and Economics)
- Participation Rates (Ontario Recreation Survey 1977-79)
- Beach Swimming Volumes (Ontario Recreation Survey 1977-79)
- Beach Widths and Effective Lengths (Ontario Recreation Supply Inventory)

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20 Anthony Usher Planning Consultant et al. (May 1987) "Beach Use and Environmental Quality in Ontario" Toronto: Policy and Planning Branch, Ontario Ministry of the Environment.

2.3 Time Period over which Forecasts are Made

Forecasts require projections of each data input. Population forecasts are readily available to 2011. In many simulations, it would be expected that age-specific participation rates would be held constant. Other variables would be held constant or altered according to the scenario being simulated.

3.0 OUTPUTS

3.1 Beach Use Forecasts

The model forecasts the number of uses of each beach.

4.0 OTHER WORTHWHILE INFORMATION

The model is formatted as a LOTUS 123 spreadsheet and can be run on an IBM-compatible personal computer.

5.0 USEFULNESS

5.1 As a Source for Beach Use Forecasts

The model's approach is commonly used for demographic-based demand forecasts. It has been severely criticized for lack of sophistication. In particular, the assumption of constant participation rates may not be very accurate for long-term forecasting. Yet, since forecasts are driven by slow-changing demographic data, the model's structure is more suited to long-run forecasting. This inconsistency casts doubt on the accuracy of the model's results.

5.2 As a Source for Forecasts of Regulatory Benefits

The model provides beach use forecasts as a function of environmental qualities. These qualities include coliform contamination, odour, water turbidity and presence of algae, other plant material, oil, grease, foam, etc. If the estimated impacts of regulatory initiatives upon these characteristics are known variables, the impact upon beach use can be determined. In addition, the model makes a preliminary economic valuation of beach use through the use of travel costs. Although simplistic, this can provide an estimate of the economic benefits to beach users of environmental protection programs.

Acid Precipitation and Recreational Fishing Activities in Ontario[21]

[Ontario Ministry of the Environment]

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

To estimate the effects of acid precipitation upon recreational fishing activities in Ontario.

1.2 Main Users

It is unknown to what extent the model is used by the Ontario Ministry of the Environment or otherwise.

1.3 Ownership

The model was commissioned by the Ministry.

1.4 Brief History of Development

The Ministry commissioned Currie, Coopers and Lybrand Ltd., in association with Earl R. Combs Ltd. and Larry Smith & Associates, to develop the model. It was completed in June 1982.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The model estimates the relationship between acid precipitation and recreational fishing activity through a variety of intermediate links: aquatic acidification to fish supply; fish supply to catch per unit of effort; and catch per unit of effort to angler occasions and related overnight stays.

The core of the model is a catch per unit effort function estimated for four provincial regions.

2.2 Estimated Period/Inputs

The model has two primary data sources. First, the Outdoor Leisure and Activity Planning Study (OLAPS) conducted by the Ministry in the Fall, 1989 provides recreational activity participation rates by age category. Second, the Ontario Ministry of Treasury and Economics provides population projections.

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[21] Currie, Coopers & Lybrand Ltd. (June 1982) "The Effects of Acid Precipitation on Recreation and Tourism in Ontario" Prepared for the Ontario Ministry of the Environment.

2.3 Time Period over which Forecasts are Made

The model can simulate the annual estimated changes in expenditures under alternative scenarios regarding aquatic acidification. Under various assumptions it can be used for projections further into the future. For example, an obvious longer-term application of the model holds the relationship between catch per unit of effort and actual recreational activity constant. In this case, the time period of forecasts are constrained only by projections of acidity levels and their impact upon fish supply.

3.0 OUTPUTS

3.1 Activity Forecasts

The model estimates changes in the annual number of angler occasions and related overnight stays resulting from aquatic acidification. Expenditures associated with these recreational fishing activities are then extrapolated.

4.0 OTHER WORTHWHILE INFORMATION

None.

5.0 USEFULNESS

5.1 As a Source for Activity Forecasts

Overall efforts to model the determinants of recreational fishing activity are modest. Although trends in demographic structure, leisure time, activity participation, income and foreign cost differentials are discussed, they are not formally incorporated into the model. Thus, as a model forecasting fishing activity, it is quite simplistic.

The purpose of the model is to estimate the impact of acid precipitation upon fishing activity. Therefore, its narrow focus is justified. It provides a useful tool to quantify the benefits of environmental protection measures related to acid precipitation.

Forecasting Activities at the Canadian Parks [22]

[Socio-Economic Branch, Canadian Parks Service]

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

To project park use expected during a peak loading period to ensure that the park design meets the need it was intended for. For example, the design of a Visitor Reception Centre at a national park must meet specifications regarding number of expected visitors to number of square metres of floor space.

1.2 Main Users

Canadian Parks Services

1.3 Ownership

Studies are conducted as needed for existing and proposed parks.

2.0 STRUCTURE OF THE MODELS

2.1 Key Functional Relationships

The models are generally multivariate regressions incorporating a variety of independent and dependent variables (see inputs and outputs respectively).

2.2 Inputs

Independent variables include: urbanization of surrounding areas, traffic on nearby highways, expected transportation upgrades and park attractiveness (which occasionally may include environmental quality).

Although user fees are sometimes included, responses are often not consistent with simple economic theory. For example, raising fees at a southern park (close to Toronto) and lowering fees at a northern park may still result in decreased attendance at the northern park. This is due to the fact that many park services are supply-constrained. Vacancies at the southern park may be filled by visitors who normally travel to the northern park in order to find a vacancy.

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[22] This discussion is based primarily upon telephone interviews with staff of the Socio-Economics Branch of the Parks Service. See also "Module 6: User Projections," undated mimeo, Parks Services.

Contact: Dr. J. Beaman, Socio-Economic Branch, Canadian Parks Service. (613) 997-6305

2.3 Time Period over which Forecasts are Made

Since forecasts for each park are made on an ad hoc basis, time periods vary according to the study's requirements.

3.0 OUTPUTS

3.1 Activity Forecasts

The models forecast a wide variety of variables, though not all may be projected for each study. In general, a bottoms-up approach is used. Forecasts are made for different categories of users before being aggregated for total demand estimates. Users are segmented into categories based on time of use, type of service used and origin of user.

4.0 OTHER WORTHWHILE INFORMATION

None.

5.0 USEFULNESS

5.1 As a Source for Activity Forecasts

A further examination on a study-by-study basis would have to be conducted to discover how many and which park studies already include environmental quality as an independent variable. These may provide a potential tool for estimating the benefits of Ontario's environmental protection programs in terms of increased use of National Parks located in the province.

Canadian Tourism Research Institute Models[23]

1.0 GENERAL INFORMATION

1.1 Purpose of the Model

To forecast tourism activities in Canada and the provinces.

1.2 Main Users

Tourism Canada, provincial ministries of tourism and members of the Conference Board of Canada (particularly large firms in air travel and accommodation).

1.3 Ownership

The Canadian Tourism Research Institute, a branch of the Conference Board of Canada.

1.4 Brief History of Development

Conference Board macroeconomic models do not include a tourism sector. In order to address this omission, the Board completed an industry model of tourism activities three years ago.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The model consists of 50-60 equations whose parameters are estimated using simple regression techniques. Each equation estimates one element of tourism activities as a function macroeconomic variables. The model can be considered a bottom-up approach since activities in each province are modeled individually and then aggregated to produce national measures.

2.2 Estimation Period/Approach/Inputs

Typical independent variables in the models includes domestic variables such as real disposable income, inflation, unemployment, gross domestic product. In addition, tourism activities from international visitors depend upon variables such as exchange rates, foreign disposable income, and relative inflation rates.

Currently the equations are estimated using 1979-1988 quarterly data obtained from Statistics Canada. The equations are re-estimated as new data become available.

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[23] Information for this section was obtained by telephone from Kip Beckman of the CTRI.

2.3 Time Period Over Which Forecasts Are Made

The CTRI regularly conducts two- to three-year outlooks. Although they are typically published on an annual-basis only, quarterly forecasts are available.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

The equations cover a four measures of tourism activity: person trips, total travel expenditures, demand for accommodation services and restaurant receipts. Person trips are estimated for both in-bound and out-bound travel. Separate forecasts are made for each province.

3.2 Frequency of Forecasts

Updated forecasts are published twice per year as part of Conference Board forecasts.

4.0 OTHER WORTHWHILE INFORMATION

The CTRI also houses an economic impact model for tourism activity -- Tourism Economic Assessment Model (TEAM).

5.0 USEFULNESS

5.1 As a Source for Macro/Commodity Forecasts

The model forecasts tourism activity in Ontario from macroeconomic variables. No regional disaggregation is available. This may pose problems in estimating tourism benefits from environmental protection measures in specific regions. The CTRI indicated that incorporating environmental quality into the model would be very difficult.

Outdoor Recreation Demand Forecasting Model[24]

[David Foot]

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

The model is used for forecasting the levels of various outdoor recreational activities using demographic trends and fixed participation rates.

1.2 Main Users

The model has been used for one academic publication. No other applications were found.

1.3 Ownership

The model was developed by Dr. David Foot, Department of Economics, University of Toronto.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The model's structure is identical to the interactive Model of Recreational Activity developed by the Ontario Ministry of Tourism and Recreation. They differ only with regards to the source of participation rates.

2.2 Estimated Period/Inputs

The model has two primary data sources. The National Recreation Surveys conducted by the U.S. Census Bureau provides age-specific participation rates. Population projections are supplied by Statistics Canada.

2.3 Time Period over which Forecasts are Made

The model generates forecasts to the year 2011.

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[24] Foot, David (1990) "The Age of Outdoor Recreation in Canada" Recreation Canada 48:5 (December):16-22.

3.0 OUTPUTS

3.1 Activity Forecasts

The model forecasts participation growth rates for 23 outdoor recreational activities including tennis, canoeing, ice skating, bird watching and pleasure driving. They are grouped into five categories: recreational sports, water-based, winter, natural environment and general. Only national growth rates are forecasted.

4.0 OTHER WORTHWHILE RELATED INFORMATION

None.

5.0 USEFULNESS

5.1 As a Source for Activity Forecasts

The same criticisms made of the Interactive Model of Recreational Activity are applicable to Foot's model. In addition, several other shortcomings exist. First, participation rates are generated from U.S. data and hence may not accurately describe Canadian activities. Second, forecasts have only been made for Canada as a whole. There are no advantages to using Foot's model rather than that of the Ontario Ministry of Tourism and Recreation.

13.0 Macroeconomic Models

Introduction

The consulting team included several experts on Canadian macroeconomic modelling activities. In addition to our own knowledge, four major published works were used for this section.[1] The most important of these is Grady's detailed study for the Department of Finance. Several other published works were of some value.[2]

Finally, recent marketing information was incorporated into the discussion below. In some cases, this was significantly different from what was generally known by the analysts. This information is attributed directly to the model "keepers." No responsibility is taken for its accuracy.

It should be stressed that up-to-date manuals for these models are not available. Competition between these modellers can be fierce and hence model developments are closely guarded trade secrets. There are no means to verify the accuracy of the information below.

All the major macroeconomic models available from private sector firms, research councils and universities were examined. Due to the large costs in constructing such models, there are only six Canadian macroeconomic models outside of government ministries. These are:

- DRI (Data Resources/McGraw-Hill);
- FOCUS (Institute for Policy Analysis, University of Toronto);
- MACE (Prof. John Helliwell, University of British Columbia);
- MTFM (Conference Board of Canada);
- TIM (Informetrica); and
- WCCM (WEFA Canada).

There are also Canadian macroeconomic models located in government ministries. These are briefly described in one section.

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1 Bodkin, R., L. Klein and K. Marwah (1991) A History of Macroeconometric Model-Building Aldershot: Edward Elger.

Daub, M. (1987) Canadian Economic Forecasting Kingston: McGill-Queen's.

Grady, P. (March 1985) "The State of the Art in Canadian Macroeconometric Modelling" Department of Finance, Government of Canada.

Uebe, G., G. Huber and J. Fischer (1991) Macroeconometric Models - An International Bibliography Aldershot: Glower.

2 Motamen, H., ed. (1988) Economic Modelling in the OECD Countries London: Chapman and Hall.

Smith, R. (1990) "The Warwick ESRC Macroeconomic Modelling Bureau: An Assessment" International Journal of Forecasting 16:3 (October):301-9.

As outlined in the Overview of Results, there are many similarities between the Canadian macroeconomic models. Macroeconomic models are generally built to understand the broad workings of the economy, including the inter-dependency of economic activities, and to estimate the economic impacts of government policies and other factors. Macroeconomic models focus upon measures of aggregate economic activity, such as gross domestic product, personal disposable income, consumption, savings and investment, foreign trade, and unemployment, interest and inflation rates.

The structures of macroeconomic models tend to be much more complex than other models examined in this report. They may include thousands of equations, some of which are behaviourial relationships estimated by econometric or other techniques. Many other equations ensure that the models satisfy accounting identities, such as savings equals income minus consumption.

Despite these similarities in overall structure and size, the specification of macroeconomic models can differ quite substantially. Delving into such detail is required to reveal these distinguishing features. We present this technical information below.

In addition, Appendix C provides for each model further information regarding the industrial disaggregation. Since few sectoral models were found, these macroeconomic models offer the most comprehensive source of forecasts for individual industrial sectors.

Data Resources/McGraw-Hill Model (DRI)[3]

1.0 GENERAL INFORMATION

1.1 Purpose of the Model

To prepare short-term quarterly forecasts, alternative scenarios and policy analysis.

1.2 Main Users

Canadian and foreign government agencies; wide variety of private sector clients.

1.3 Ownership

The model is the property of DRI/McGraw-Hill of Toronto.

1.4 Brief History

The DRI model draws its roots from two sources, the first that of Otto Eckstein and others at Harvard (who founded the original parent DRI in the U.S.), the second Thomas Wilson and others at the University of Toronto. It evolved from annual to quarterly in nature over the years, and has added various components including energy and regional elements. In recent times DRI has come to be controlled by McGraw-Hill, but as a separate entity. At present, the main group of model "minders" includes George Vasic, among others.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

"The DRI model has six blocks: 1) the income-expenditure, employment, potential GNP block; 2) the price-wage block; 3) the industry output block; 4) a financial block; 5) a balance of payments and exchange rate block; and 6) an energy block." [Grady (1985)].

There are eleven consumption categories, three residential investment ones; business investment is available for plant and equipment for all sectors; three inventory categories, all government level groups, and ten merchandise and three services categories exist for imports and exports. Certain of the trade variables are linked to similar variables in other DRI models in Europe, U.S., and Japan.

It is basically a Keynesian model with respect to design [company description, 1991].

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[3] Contact: George Vasic, Data Resources Canada. (416) 961-9323

Sectors can be characterized as follows:

> "Consumption: permanent income
> Investment in Residential
> Construction: key equation for housing starts primarily demand driven
> Investment: cash flow augmented neoclassical stock-adjustment model embodying a replacement investment hypothesis
> Government Expenditure: federal/provincial; current federal are exogenous in either real or nominal terms; current provincial can be either endogenous or exogenous, if exogenous, can be nominal or real; federal and provincial investment are exogenous in real terms
> Exports: demand; primarily price setter
> Imports: demand; price taker
> Prices: cost mark-up using input/output data to relate industry prices to final demand prices; industry prices are explained in a stage-of-processing price model
> Price Expectations: adaptive
> Technology: Cobb-Douglas in aggregate; stage-of-processing by industry
> Factors of Production: capital M&E; capital non-res; labour; energy
> Wages: extended Phillips curve
> Exchange Rate: eclectic with interest rate differentials, basic balance, portfolio considerations; and expectations" [Grady (1985)]

2.2 Estimation Period/Approach/Inputs

The model, in its latest version, is estimated over the post-war period using 1986 re-based national accounts.

It contains about 600 equations, of which some 225 are stochastic. There are about 250 exogenous variables used in the models (important U.S. "driver" variables are obtained from DRI's U.S. models).

The model is a quarterly one and uses the company's proprietary software system (EPS). Data are drawn from STATCAN'S CANSIM mini-base, and certain other sources such as the Canadian Tax Foundation and the Bank of Canada.

2.3 Time Period Over Which Forecasts Are Made

DRI produces short-term (up to three year) forecasts eight times per year, and long-term ones (ten to twenty-five years) four times per year.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

Variables forecast include the numerous categories of macro variables one would expect of a model of this type and size i.e., income, consumption, investment, government spending,

export/imports, savings, taxes, inventories, monetary aggregates, interest and exchange rates, prices, housing, etc.

As well (see below for details), output is modelled, using an Industry "Model", for 43 industries (at the 1980 2-digit SIC level), and ten aggregates; and for seven regions of the country (using a Regional "Model").

3.2 Frequency of Forecasts

As noted above, the frequency of forecasts varies for term from those using the Macro model, to those associated with industry/regional breakdowns. For example, industry breakouts are available quarterly (out to three years) and annually for longer terms, while regional ones are done four times a year, twice out to three years, twice out to ten years.

3.3 Capability to Forecast Outputs by Specific Facilities Within Specific Industry Groups in Ontario (i.e., Ontario applicability)

While DRI/McGraw-Hill has disaggregated output over industries, it is essentially (the word is used deliberately as there is a bit more to it than this) shift-share[4] via the I/O tables, and thus what one would do in any event. The same is true of the regional model.

Forecasts to the level of individual detail (specific facilities) could, in principle, be approximately arrived at using both filter approaches (and further "shift-sharing" to the individual facility level). This has not been done to the present.

4.0 OTHER WORTHWHILE INFORMATION

DRI/McGraw-Hill also has a detailed Energy Model which is tied in with its Macro/Regional/Industry configuration. It develops prices and demands for major fuels, and for electricity, by demand user category, on a provincial basis. It also translates electricity demand into generation requirements, and determines fuel consumption and costs. This model, while clearly most suited to energy-related issues, could also be used as part of more general total package to assess environmental impacts/costs. A detailed description of the energy model is attached at the end of this model assessment.

It should also be noted that a version of the DRI/McGraw-Hill model may be available for use on a PC.

5.0 USEFULNESS

5.1 As a Source for Macro/Commodity Forecasts

[4] "Shift-share" techniques make use of input-output tables to allocate aggregated production to individual industries. The exercise assumes that industry shares of aggregate output are essentially fixed.

The model has been widely used by numerous parties in government and industry to perform macroeconomic forecasts and simulations. It would be a useful source of macroeconomic forecasts. It is not a commodity forecasting model, per se however, except for those SICs which happen to be identified with a single commodity (such as iron ore and electricity). Because of its regional/energy configuration, it is likely the most complete of the model families reviewed.

5.2 For Forecasting Emissions, Effluents and Solid Wastes, and for Estimating the Impacts of Environmental Regulations

As with the other models here, and in spite of its "completeness", a post-processor[5] would still need to be developed to translate the model's production forecasts into pollution-generation forecasts through accounting identities. Unfortunately the model's production functions do not incorporate pollution generation variables as endogenous factors of production. Moreover, the input-output matrix embedded in the model implies a single, static, average technology for each industry, instead of multiple technologies (with differing pollution rates) from which to choose. The model could be used to simulate the costs of environmental regulations through the diversion of investment to "non-productive" uses.

6.0 THE CANADIAN ENERGY MODEL OF DRI/MCGRAW-HILL[6]

The Canadian Energy Model develops the prices and the demands for the major fuels and for electricity in the residential, commercial, industrial, and transportation sectors on a provincial basis. The model also translates the electricity demands into the generation requirements and determines the fuel consumption and costs (average electricity price) associated with the generation process in the electric utility sector of the Model. Pricing in the Energy Model and demands by sector are discussed below.

Economic Determinants of Energy Demand

Macroeconomic information is obtained from the DRI Canadian Economic Service, which makes use of a dynamic, general equilibrium model. This service provides the energy model with information on such things as exchange rates, interest rates, investment, unemployment rates and price indices. These inputs are then regionalized for use in the Canadian Energy Model. To maintain consistency, the Canadian Macroeconomic Model recovers some inputs from the results of the energy model solution which are then aggregated back to the national level for use in the next simulation of the macroeconomic model.

The Canadian Regional Service provides forecast values for the energy model for such concepts as the provincial breakdown of demographic, macroeconomic and industrial output variables,

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5 "Post-processor" refers to emissions forecasting models which use economic forecasts as an input. The most common are merely matrices giving pollution-generation per unit of production. After economic activity is forecasted, production is simply multiplied by these generation factors to forecast pollution generation.

6 Information given here is based directly on that supplied by the organization.

including agriculture and forestry. Once these inputs have been obtained from the other DRI services, supply and demand balances are determined by solving the simultaneous energy model. in the model, supply is both a reflection of outside information and a result of price levels. Energy demand is rigorously determined as a combination of capital stock, utilization, inter-fuel substitution, conservation, and economic growth.

Energy Prices

Energy prices are the most important part of the model's forecasting properties. The DRI World Oil Model, which is a direct input into the Canadian energy model, is the source for information on both the historical and forecasted values of the world oil price. The Calculation of the world oil price has incorporated the assumptions and expected trends of the Canadian, U.S. European, and Japanese macroeconomic and energy services. The world oil price is then translated into wholesale prices for oil in Canada. Petroleum product prices are derived from refinery costs, the return on assets employed in refining, and the cost of crude oil.

Wellhead natural gas prices are modeled as a function of the petroleum product prices, domestic demand and exports. Citygate and delivered-to-consumer natural gas prices are then determined from the wellhead price plus any taxes and transportation charges.

Electricity rates are determined from the average cost of electricity within each region. The average costs of electricity supply depends on capacity additions, interprovincial transfer exports, fuel costs, operation and maintenance, debt service, taxes, and other costs.

Energy Demand

The energy demand model consist of six sectors — residential, industrial, commercial, transportation, electric utility, and energy exports. Demand is forecasted for the seven regions and Canada as listed in Table A1. Table A2 provides an idea of the scope of coverage provided within the energy model. This model also incorporates an end-use model that determines the reference demand of the various provinces using capital stocks, market penetration, market saturation and energy intensity coefficients.

The residential sector utilizes such factors as heating degree days, relative energy prices and personal disposable income. Appliances and saturation rates, energy usage of appliances, and number of households are used to forecast the reference demand which then combines with the operator inputs to model actual residential demand.

The industrial sector utilizes energy use coefficients and real domestic product to calculate the reference demand. By combining reference demand with the fuel prices from the energy-pricing model, a forecast of industrial demand is then broken down into demand by fuel type.

The commercial sector begins with a forecast of investment and commercial floorspace which is then used to determine a reference demand for the commercial sector. Energy prices again play an important role in forecasting total commercial demand as do commercial employment, personal income and weather conditions.

Inter-fuel Substitution

The issue of inter-fuel substitution has also been incorporated into the model, and the changes in demand for oil, gas, electricity, coal and wood are caused by changes in the price of any one of these fuels. Inter-fuel substitution occurs at several levels in the model. The choice of home heating fuel is largely determined by life cycle costs using current prices and adjustments for expectations. Price differentials are also a primary concern to consumers in the residential sector. The commercial sector relies on floorspace and the past trends in energy usage-per-employee to determine the total energy demand. However, prices play a major role in affecting the type of energy to be used. In industry, the availability of alternative fuels is a major consideration, as are the adaptability and feasibility of that fuel to the process used by the industry. Inter-fuel substitution is modeled so that the gains accruing to one fuel are offset by reductions in others.

Summary

The energy model, with its many policy levers, is ideally suited to doing impact studies when new policies are implemented, taxes are changed or pricing schemes are altered. By changing one or more of these levers to reflect changes in the energy markets and resolving the model, analysis of the economic impacts of the energy policies can be done for GNP, inflation, employment, balance of trade and industrial production.

Federal Government Models[7]
[CANDIDE, RDX2/RDXF/SAM, QFS,]

1.0 GENERAL INFORMATION

1.1 Purposes of the Models

There are a series of models, extant and otherwise, which are available (or have been) to the Federal Government and the Bank of Canada to generate forecasts, and simulate policy responses. They are able to generate short, medium and long-term forecasts as required.

1.2 Main Users

Bank of Canada and the Department of Finance principally as well as Agriculture (with its own models), and certain other departments. The Economic Council, which originally developed and maintained CANDIDE, no longer does so relying instead on outside models (e.g., the Conference Board, WEFA-U.S., and others).

1.3 Ownership

These models are "owned" and maintained by the Federal Government of Canada, and the Departments in question (e.g., RDXF and SAM by the Bank of Canada; QFS by the Department of Finance).

1.4 Brief History of Development

All of these models originated in the Federal Government and date from the earliest econometric modelling efforts in this country. For a history of their development see Daub (1987) or Bodkin et al (1991). At present, RDXF/SAM (Small Aggregate Model) at the Bank, and QFS (Quarterly Forecasting and Simulation) are the only really extant ones, the others (principally RDX2 and CANDIDE) having fallen by the wayside. These models date from the mid to late seventies, with refinements since.

2.0 STRUCTURES OF THE MODELS

"RDXF is a quarterly model in the Keynesian tradition. It is largely demand driven in the short-run with comparatively weak supply constraints. A major outlet for demand is provided by imports which put pressure on prices through the exchange rate....

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[7] Because of severe problems of likely availability to the Ministry of Environment (Government of Ontario) due to proprietary considerations, the treatment of these models has been abbreviated, and consolidated into one group. The intention is simply to indicate briefly what is available inside the Federal Government if the Ministry wishes to pursue it (there is also a matter of usefulness - see comments on SAM, for example).

SAM is an annual model incorporating three goods: energy; commercial non-energy output and a foreign non-energy good. Only the supply of non-energy output is endogenous. It is a function of capital, labour and energy usage. The real price of energy is exogenous. Energy trade is treated as exogenous so as not to destabilize the current account balance. This requires energy output to be endogenously determined in order to balance energy supply and demand. Domestic energy demand is endogenous as a factor of production for the non-energy good. The foreign non-energy good is an imperfect substitute for domestic output. Thus the import and export equations depend on relative prices. In accordance with the small country assumption, the price in foreign currency of imports is exogenous....

QFS is a quarterly model which is similar in structure to the RDX series of models developed at the Bank of Canada. Real demand determines output in the short to medium run. Aggregate supply is based on a single Cobb-Douglas production function with four factors, machinery and equipment, structures, labour and energy. This aggregate supply is utilized in employment, investment, and energy demand equations. Imbalances between supply and demand equations have an impact on wages and prices through the labour market gap and inventory disequilibrium variables. It also has an extensive energy sub-sector." [Grady (1985)].

All of these models are estimated on post-war data, and are up to date. They are of varying size (e.g., RDXF has about 400 equations, SAM around 130, and QFS about 600).

3.0 OUTPUTS/USEFULNESS

Variables forecast include the numerous categories of macro variables one would expect of models of this type and size. None of the models, except for now-departed CANDIDE, have regional, or industrial, breakouts.

While they have been widely used by many in government for forecasting purposes they are entirely macro in nature, focusing on national projection and monetary and fiscal simulation and are thus of little potential use for provincial, site specific environmental simulation. As also stated above, while some may be available to the Ministry (e.g., SAM), others are definitely not (e.g., QFS), even were they relevant (which they are not!).

FOCUS[8]

[Forecasting and User Simulation Model]

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

The model is used for forecasting, policy and simulation analysis. Emphasis is on the medium to long-term.

1.2 Main Users

The results of the analysis go mainly to the subscribers of the Policy Analysis Program, Institute of Policy Analysis at the University of Toronto. These subscribers consist largely of business and governments.

FOCUS is also the Canadian model used in Project LINK, the large international jointly-linked modelling exercise originally begun by Lawrence Klein (University of Pennsylvania).

1.3 Ownership

The FOCUS model was developed, and is maintained, at the Institute of Policy Analysis, University of Toronto.

1.4 Brief History of Development

FOCUS draws its heritage from the long-standing modelling efforts at U. of T. begun originally by John Sawyer and others around the TRACE annual model. These early efforts led eventually to the recognized need for a quarterly model, to which Gregory Jump and others contributed, and which was known as QFM. QFM was supplemented by FOCUS, again under Jump's influence. It has been re-estimated recently by Peter Dungan who is the major model "minder" at present. Thomas Wilson, too, has had an important influence on all of this work reaching back to the seventies.

[8] Contact: Peter Dungan, Institute of Policy Analysis. (416) 978-4128

2.0 STRUCTURE OF THE FIRM

2.1 Key Functional Relationships

FOCUS is a neo-Keynesian quarterly model using the well-known IS-LM-BP approach,[9] through Aggregate Demand/Aggregate Supply analysis, to organize the equations.

"The Investment-Savings schedule, which shows the level of aggregate demand corresponding to a given real interest rate, is represented by equations for consumption, investment, government spending, and exports and imports as well as for the various components of income. Approximately 55-60 percent of the equations in the model fall into this block. The key price variable in the model is the implicit price index for privately-produced GDP. It contains two alternative price regimes: one based on a mark-up of labour, import, tax and petroleum costs; and another based on a neoclassical market clearing process which determines prices by equating aggregate supply and demand. Another distinguishing feature of FOCUS is its use of "synthetic" expectation variables consistently throughout the model. The synthetic expectations series represent expected inflation 90 days, one year, and two years ahead... The LM block of the model is more compact than the IS representing some 10-15 percent of the total number of equations. It includes the equations for interest rates and the supplies and demands for various financial assets. The main link between the financial and real sectors is interest rates. The key interest rate is the ex ante real rate of interest on 90 day paper. It is determined by equilibrating the supply and demand for money. The model allows for several definitions of money. Other interest rates are generated by estimated term structure relationships. The exchange rate is also determined by a market clearing mechanism. It is the price that clears the balance of payments." [Grady (1985)]

Sectors can be characterized as follows:

"Consumption: permanent income
Investment in Residential
Construction: availability of mortgage funds determines demand
Investment: non-residential construction function of difference between after-tax real rate of return on investment and real interest rate; machinery and equipment is based on modified Jorgenson model; cash flow affects rate of adjustment
Government Expenditure: federal/provincial split; real exogenous
Exports: demand; some price taker; others price maker
Imports: demand; price taker
Prices: Two Options: market clearing; and mark-up
Price Expectations: synthetic expectations based on regression of inflation on variables considered important by market participants; used consistently throughout model
Technology: Cobb-Douglas for private sector made up of N identical plants
Factors of Production: capital M&E; production labour
Wages: extended Phillips curve

[9] The IS-LM-BP framework is a standard macroeconomic modelling approach. The framework produces three basic schedules representing investment-savings (IS), liquidity-monetary (LM) and balance of payments (BP) activities. See any intermediate macroeconomic textbook for a detailed explanation.

Exchange Rate: determined as market clearing price for disaggregated capital flows/balance of payments sector" [Grady(1985)]

2.2 **Estimated Period/Approach/Inputs**

The model is estimated from post-war data, updated to the present i.e., to include the 1986 re-based national accounts.

It has 300+ equations (344 according to one source), of which roughly half are stochastic. There are approximately 17.5 exogenous variables (important U.S. "driver" variables are obtained from WEFA U.S. through Project Link relationship).

The model is a quarterly one and uses a FORTRAN simulation and estimation package at the U. of T. Computer Centre. Data are drawn from Statistics Canada.

2.3 **Time Period over which Forecasts are Made**

Being a quarterly model, forecasts are available over any horizon next quarter out to, for example, two years, or beyond.

3.0 OUTPUTS

3.1 **Economic and/or Commodity Forecasts**

Variables forecast include the numerous categories of macro variables one would expect of a model of this type and size i.e., income, consumption, investment, government expenditures, exports, imports, savings, taxes, inventories, monetary aggregates, interest rates, exchange rates, prices, housing, labour force/population/employment, wages, and so on.

The model does not forecast individual sectoral output, or commodity output and prices directly. That is done by a satellite model, PRISM, which is detailed in Section 6.0 following.

3.2 **Frequency of Forecasts**

Updated forecasts are published quarterly for PEAP and other uses. It should be noted that while FOCUS is quarterly, PRISM is annual in nature.

3.3 **Capability to forecast outputs by Specific Facility Within Specific Industry Groups in Ontario (i.e., Ontario Applicability)**

FOCUS, through PRISM, is able to forecast individual sectors within the Ontario economy (see description in Section 6.0 below). Forecasts to the level of specific facilities could in principle be obtained using shift-share techniques.

4.0 OTHER WORTHWHILE INFORMATION

FOCUS is somewhat special in that it offers a wide variety of policy lever variables for selecting alternative fiscal, monetary and other regimes. This could potentially be of some value with respect to environmental policy if in no other way than through fiscal expenditure implications simulations.

5.0 USEFULNESS

5.1 As A Source for Macro/Commodity Forecasts

The model has been widely used by numerous parties in government and industry to perform macroeconomic forecasts and simulations. It would be useful source of macroeconomic forecasts. It is not a commodity forecasting model. It does have a wide variety of policy lever variables. And through PRISM one could in principle obtain forecasts to the level of individual sectors in Ontario.

5.2 For Forecasting Emissions, Effluents and Solid Wastes, and For Estimating the Impacts of Environmental Regulations

The same comments made for DRI apply to FOCUS.

6.0 A BRIEF DESCRIPTION OF PRISM - PRovincial-Industrial Model of the Canadian Economy)

Prism is an acronym for PRovincial-Industrial Satellite Model. The model was constructed and is maintained at the Institute for Policy Analysis, University of Toronto. The current version distinguishes 55 sectors and was released in June 1989. PRISM operates as a satellite model to the FOCUS national macroeconometric model which determines results for various "national" markets. PRISM then works from these national aggregates to break out detail for industrial production and employment, and provincial production, employment and income. FOCUS is of "medium" size (500+ variables, 300+ endogenous) and relatively complex in its specifications and degree of simultaneity. PRISM is virtually recursive. It should be noted that while FOCUS is a quarterly model, PRISM is annual; FOCUS series are automatically annualized on being fed into PRISM.

The national industrial detail in PRISM consists of real domestic product (value added), employment, and domestic-product deflators for 54 industries, plus government (55 Basic Sectors). This industrial detail is developed from the real final demands from FOCUS via an (inverse) input-output matrix, which allows also for all required intermediate production. Sectoral detail in PRISM is forced to add to national aggregates obtained from FOCUS. These sectors are as follows:

1	AG	Agriculture	30	CN	Construction
2	FR	Forestry	31	TW	Water Transport
3	FI	Fishing, Hunting & Trapping	32	TR	Rail Transport
4	MM	Metal Mines	33	TT	Truck Transport

5	MP	Petrol & Gas Wells
6	MN	Non-Metal Mines & Coal
7	MQ	Quarries & Sand Pits
8	MO	Other Mines
9	FB	Food & Beverage
10	TB	Tobacco
11	RP	Rubber & Plastic
12	LT	Leather
13	TX	Textiles
14	CK	Clothing & Knitting
15	WP	Wood Products
16	FF	Furniture & Fixtures
17	PP	Pulp, Paper & Allied
18	PR	Printing & Publishing
19	PM	Primary Metal Products
20	MF	Metal Fabricating
21	MC	Machinery
22	BM	Business Machines
23	MV	Motor Vehicles & Parts
24	OT	Other Transport Equipment
25	EP	Electrical Products
26	NM	Non-Metallic Products
27	PC	Petrol & Coal Products
28	OH	Chemical Products
29	OM	Other Manufactures
34	TP	Pipeline Transport
35	TA	Air Transport
36	TU	Urban Transport
37	TO	Other Transport
38	TM	Transport Margins
39	SW	Storage
40	CR	Radio & TV Broadcasting
41	CT	Telephone & Other Communications
42	CP	Post Office
43	UE	Electric Utilities
44	UG	Gas Utilities
45	UW	Water & Other Utilities
46	TD	Wholesale & Retail Trade
47	OD	Owner Occupied Dwellings
48	RY	Provincial Resource Royalties
49	BI	Banks & Insurance
50	OF	Other F.I. & RE
51	SE	Education Services
52	SH	Healter Services
53	SP	Personal Services
54	SB	Business Services
55	GV	Government
56	MA	Manufacturing
57	GD	Goods-Producing
58	SV	Services

The provincial detail in PRISM depends first and foremost on provincial shares of the outputs of the different industrial sectors (i.e., for the same 55 basic sectors as are available nationally). Many of these shares are exogenous to the model, but those for most tertiary sectors (e.g., services, finance) are related to provincial real output or provincial population. Applying the shares to national industrial outputs (real and nominal) and summing across sectors yields provincial real and nominal gross domestic products. Thus PRISM is distinctly "top-down" in its approach: variables are determined in aggregate and then broken down into the component detail — whether for sectors or provinces.

The MACE Model[10]

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

The model is primarily used to simulate and do policy analysis, especially to examine links between the energy sector, and the economy more generally.

1.2 Main Users

Academics, government at all levels, large corporations

1.3 Ownership

The model is the property of Prof. John Helliwell, University of British Columbia.

1.4 Brief History of Development

MACE came into being in the late 70's, early 80's as a response to two factors, the first a concern of Helliwell's that econometric models were becoming too large (he had helped build RDX2 at the Bank, and was influential for this reason, in the development of SAM), and second, that a specific, energy related model was necessary to analyze the various oil shocks, pipeline proposals, etc. that were impacting the economy during this period.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

"MACE is an annual model which has two main industrial sectors, one is the energy producing, and the other uses labour, capital, and energy to produce everything else. The output of the energy using sector is imperfectly substitutable for non-energy imports, but to an equal extent for all final demands. It is also substitutable but to a different degree for foreign output....The energy sector has six main blocks of equations: 1) the demand block; 2) the Arctic pipeline block; 3) the non-frontier natural gas supply sector; 4) the non-frontier crude oil supply sector; 5) the oil sands supply sector; 6) a final block modelling energy transportation and losses and alternative systems for linking energy revenues to equalization payments." [Grady (1985)].

Sectors can be characterized as follows:

> "Consumption: life cycle model based on the after-tax wage and transfer income and the real value of household wealth
> Investment in Residential

[10] Contact: Dr. John Helliwell, University of British Columbia. (604) 822-2876

Construction: treated as part of non-energy capital investment
Investment: for non-energy sector is a function of gap between desired and actual capital stock based on technology and productivity costs relative to output price
Government Expenditure: no federal/provincial split; exogenous in real terms
Exports: both demand (world income & relative price) and supply (inventory disequilibrium); price based on foreign prices and domestic costs
Imports: demand; price taker
Prices: cost mark-up extended to include difference between actual and desired inventory stocks
Price Expectations: adaptive; not explicitly modelled
Technology: vintage CES (Constant Elasticity of Substitution) bundling of energy and capital nested within a Cobb-Douglas function for gross output based on the bundle and efficiency units of labour
Factors of Production: capital-plus-energy; efficiency units of labour
Wages: function of percentage change in labour productivity, the price of absorption, the terms of trade and gross output relative to supply; unemployment dropped from latest version of model
Exchange Rate: several alternative regimes; portfolio model with limited intervention allows for exchange rate smoothing capital flows; exchange rate clears current account and net capital inflows." [Grady (1985)].

2.2 Estimation Period/Approach/Inputs

The model is estimated from post-war data updated to the present. It has about 50 equations in the macro block, about 550 in the energy block. There are 20 or so exogenous variables in the former, about 100 in the latter.

The model is an annual one and uses a Bank of Canada simulation package.

2.3 Time Periods over Which Forecasts are Made

Forecasts are available over various periods out to relatively long term horizons.

3.0 OUTPUT/USEFULNESS

In addition to the usual macro variables one would expect to see forecast (e.g., consumption, etc.), albeit in a very stripped-down way, one sees a host of energy sector-related variables such as net energy imports, inventory changes, prices, energy transportation costs, and so on.

The model does not have an industry dimension outside the energy block, nor is it regionalized. Thus, while it is "energy-intensive", it is regionally deficient in other industrial sectors.

Thus insofar as the interests of the Ministry are concerned, it is least useful in a general way; more relevant to energy/environmental impacts. On balance, though, it is likely not of as much value as certain other models reviewed here.

The Medium Term Forecasting Model (MTFM)[11]

[Conference Board in Canada]

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

To generate short and medium-term alternative forecast scenarios, and do some policy analysis.

1.2 Main Users

The results of the analyses go mainly to the Associates of the Conference Board, which includes many of Canada's largest corporations, and some governments.

1.3 Ownership

The model is the property of the Conference Board in Canada (Ottawa).

1.4 Brief History of Development

The MTFM model draws its roots from the work done at the Bank of Canada in the early '70s on RDX2. Tom Maxwell, one of that model's architects, left the Bank on completion of that work to join the Conference Board where he built their first model, AERIC, an annual model (and helped develop the software system, TROLL, to support it). MTFM came to supplant AERIC in the early 80's because of the need for quarterly forecasts. Various individuals have contributed to its development over the years including Peter Gussen, Anseln London, Jim Frank and others.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

"The MTFM quarterly model is characterized by its builders as "based on the neoclassical synthesis". It is multi-sector. Investment, employment, wages and prices for the sectors are dependent on sector production functions. As with most models, in the short-run output is primarily expenditure determined, but there are supply side feedbacks on prices, imports, exports and thus output from sector capacity constraints... The model is structured in fourteen blocks: 1) consumer expenditures; 2) housing and residential construction expenditures; 3) non-residential fixed investment and inventories; 4) government current expenditures; 5) imports; 6) exports; 7) output; 8) employment, hours and labour force; 9) prices; 10) income distribution; 11) taxes and transfers; 12) financial markets; 13) international capital flows and exchange rates; and 14) energy." [Grady 1985)].

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[11] Contact: John Higgins, Conference Board of Canada. (613) 526-3280

Sectors can be characterized as follows:

> "Consumption: eclectic including permanent income, relative prices, expected real rate of interest and consumer confidence Investment in Residential Construction: equations for single and multiple units incorporate demand elements and government housing assistance and a supply element, the profitability of housing starts Investment: Jorgenson neoclassical investment model for a number of industrial categories
> Government Expenditure: federal/provincial split; real exogenous
> Exports: supply and demand; price taker fro some commodities, price setter for others
> Imports: demand; price taker
> Prices: cost mark-up incorporating stages of processing
> Price Expectations: adaptive
> Technology: no explicit production function; implicit production functions in employment demand and investment equations are Cobb-Douglas
> Factors of Production: in industry employment equations have M&E and non-res
> Wages: reduced form equations by industry incorporating both labour supply and demand factors
> Exchange Rate: inverted short-term capital flow equation; determined by basic balance, and change in interest rate differential; does not include a lagged stock adjustment term for short-term capital" [Grady (1985)]

2.2 Estimation Period/Approach/Inputs

The model is estimated over the post-war period updated to the present i.e., to include the 1986 re-based national accounts.

It contains about 900 equations, of which approximately 300 are stochastic. There are about 800 exogenous variables used in the model (Important U.S. "driver" variables are obtained quite often from WEFA U.S., as well as other sources)

The model is a quarterly one and uses the Board's proprietary software system TROLL. Data is drawn from STATS CAN, and certain of the Board's own statistical series.

2.3 Time Period Over Which Forecasts Are Made

Being a quarterly model, forecasts are available theoretically over time horizons stretching from next quarter out to, for example, ten years. In practise, the Board seldom, if ever, issues forecasts beyond two years (eight quarters), although these is no reason why they could not.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

Variables forecast include the numerous categories of macro variables one would expect of a model of this type and size i.e., income, consumption, investment, government expenditures, exports/imports (MTFM has a most extensive external sector), savings, taxes, inventories,

monetary aggregates, interest and exchange rates, prices, housing, labour force, wages and so on.

As well, output (and employment as well) is modelled for forty industries using recent input/output tables. "These include agriculture, other primary (6), manufacturing (20), construction, commercial services (12), and public admin/defence....MTFM does not contain industry production functions." [Grady (1985)].

3.2 Frequency of Forecasts

Updated forecasts are published regularly throughout the year on at least a quarterly basis, sometimes more frequently.

3.3 Capability to Forecast Outputs By Specific Facilities Within Specific Industry Groups in Ontario (i.e., Ontario Applicability).

While MTFM does disaggregate output over forty industries, the approach used is of a shift-share nature using the I/O tables and thus what one would do in any event (albeit one step in the work is saved). MTFM does not regionalize industrial output. A separate model, PC Ontario, is available to forecast Ontario industrial activity. See below for a description of PC Ontario.

4.0 OTHER WORTHWHILE RELATED INFORMATION

Non-residential investment in MTFM is broken into machinery (equipment and non-res.categories including agriculture, other primary, manufacturing, construction, commercial services, non-commercial, petroleum/gas mining, petroleum/coal products, and electricity/pipelines/gas distribution.

MTFM has a detailed energy sub-model, as well as a model of the Ontario economy (see below). Both may be of some marginal value in modelling environmental impacts.

It should also be noted that a version of MTFM is available for use on a PC.

5.0 USEFULNESS

5.1 As a Source for Macro/Commodity Forecasts

The model has been widely used by numerous parties in government and industry to perform macroeconomic forecasts and simulation. It would be useful source of macroeconomic forecasts. It is not a commodity forecasting model, however, except for those SICs which happen to be identified with a single commodity (such as iron ore and electricity). It does have sectoral detail; is a good, general, quarterly model; and is the "most found in the popular press" of all the models reviewed here.

5.2 For Forecasting Emissions, Effluents, and Solid Wastes, and For Estimating the Impacts of Environmental Regulations

See the comments made for DRI.

6.0 The Conference Board's model of the Ontario Economy[12]

The Conference Board also houses a model of the Ontario economy. Designed to run on a personal computer, PC Ontario was developed for the Ontario Ministry of Treasury and Economics for their internal use. It is a fully simultaneous macroeconomic model.

A brief model overview is given below that should be sufficient for Ministry requirements. While the Conference Board provides its clients with detailed model documentation, this material is not published.

There are 163 equations in the model (105 stochastic equations and 58 identities) and 400 variables. The Conference Board maintains the model on an ongoing basis and can provide a 20 year base case model solution.

There are more than 20 final demand categories -- personal consumption, investment, government spending, and international and interprovincial merchandise exports, other exports and imports -- in PC Ontario. Final demand is modelled in real terms using provincial specific price deflators that were provided by the Ministry of Treasury and Economics. Provincial final demand prices are endogenous in PC Ontario. That is they are determined by the model. They are a function of wage rates, capital costs, raw material prices and market conditions. Market conditions are a function of the gap between potential output and actual output.

PC Ontario has more than 30 industry Gross Domestic Product (GDP) disaggregations and 5 employment groups. In the model, GDP is a function of final demand and employment is in turn determined by output and productivity. Average weekly wages are modelled as a function of GDP growth, real interest rates and the change in price expectations. In the short run, money illusion can occur, but over the longer run, it cannot. Employment and average wages yields wage income which combined with farm income, corporate profits, interest income, and capital consumption allowances determines GDP at factor cost. The impact of all major indirect taxes on final demand prices are modelled separately but subsidies are exogenous.

Before feeding back into final demand (e.g. personal consumption), income is adjusted for transfers to persons and transfers to government to yield personal disposable income. Interest rates and relative prices are also key determinants of final demand.

A variety of other key economic variables such as population, labour force, the unemployment rate, retail sales, housing starts, and the Consumer Price Index are included in the model.

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12 Information given here is based directly on that supplied by the organization.

In summary, the Conference Board's PC Ontario model is a simultaneous macroeconomic model of the province. There are more than 20 final demand and 25 industry output categories. Unlike many other provincial models, the trade sector is broken down into exports and imports (international and interprovincial) and provincial specific price deflators are endogenous in the model.

The Informetrica Model (TIM)[13]

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

To generate short, medium and longterm forecasts, alternative scenarios, and for policy analysis. Has also been used in a limited way for environmental assessment.

1.2 Main Users

Large Canadian Corporations, government at all three levels.

1.3 Ownership

The model is the property of Informetrica, Ltd. of Ottawa.

1.4 Brief History of Development

The Informetrica Model draws its roots from the work done by the President of Informetrica, Mr. Mike McCracken, as the principal architect of the original CANDIDE model, built for the Economic Council of Canada. On leaving the Council at the completion of the CANDIDE project in the early 1970's, Mr. McCracken formed Informetrica, and developed his own models, the Informetrica Model (TIM) and the Regional Industrial Model (RIM), which have been steadily refined since into their present forms.

2. STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

"The real sector of the model has: 1) a final demand block consisting of consumption, investment, government, exports and imports; 2) an industry output block generating RDP (Real Domestic Product); and 3) a labour market block incorporating demography, labour demand and supply and unemployment. The price side of the model is contained in a final demand price block and an income block which also provides the links between sector expenditures and incomes which comprise the heart of the GDP identities associated with the national accounts framework. Interest rates and other financial variables are determined in another block so as to be consistent with the money supply and the level of economic activity. There is also an input/output submodel which integrates the real and price sides of the model and provides a bridge from final demand to industry output and from domestic industry prices and foreign prices to domestic final demand prices." (Grady (1985)) The model is essentially Neo-Keynesian with a large imbedded I-O model.

[13] Contact: Carl Sonnen, Informetrica Ltd. (613) 238-4831

Sectors can be characterized as follows:

"Consumption: Houthakker-Taylor specification
Investment in Residential Construction: primarily demand-driven stock adjustment model
Investment: disaggregated by industry; specifications generally based on Jorgenson neoclassical model, but also on cash flow and flexible accelerator models
Government Expenditure: Federal/provincial/hospitals/local government/pensions split; many categories of spending are endogenous
Exports: demand; primarily price taker but for some items prices setter
Imports: demand; price taker
Prices: cost add-up based on input/output disaggregation including producer prices and surplus
Price Expectations: adaptive
Technology: Cobb-Douglas by industry with some exceptions
Factors of Production: capital M&E; Capital non-res; employment; disaggregated by industry
Wages: Modified Phillips curves by industry tied to manufacturing but with role for industry specific labour market conditions; separation of wages and supplementary labour income
Exchange Rate: exogenous

2.2 Estimation Period/Approach/Inputs

The model is estimated over the post-war period updated to the present, i.e., to include the 1986 re-based national accounts.

It contains approximately 9400 equations, of which about 2200 are stochastic. There are about 4000 exogenous variables. Key U.S. "driver" variables are obtained from Lawrence H. Meyer and Associates, Ltd., U.S., and other sources.

The model is an annual one and uses Informetrica proprietary software. Data is drawn from Statistics Canada and certain of Informetrica's own (again proprietary) statistical series.

2.3 Time Period Over Which Forecasts are Made

National forecasts are available annually over any horizon to 2020.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

"Personal expenditures are disaggregated into 64 categories of personal consumption. Final demand expenditures of the business sector are broken down into investment in inventories, nonresidential and residential construction, and machinery and equipment which are further disaggregated by 60 industry/government sectors. Both current and capital expenditures are distinguished in final demand for the government sector. There are five levels of government -

federal, provincial, local, and hospitals and government pension plans. The foreign sector through exports is a source of final demand and some portion of final demand is satisfied through imports.

Industry output is a key concept integrating expenditure and economic activity. The various categories of industry output are utilized in the determination of imports, exports, inventories, business investment, and employment. Industry outputs are used in the determination of factor incomes, which are in turn employed in the determination of current dollar industry output and the corresponding prices of industry activity. The input/output system is also utilized to link final demand expenditure to industry output and to link industry prices, import prices and indirect taxes to final demand prices.

The outputs of the labour sector are labour force, employment by industry, and unemployment. The unemployment rate enters many parts of the model as an indicator of the state of the economy. Employment by industry is used in determining the factor income of labour, a key concept in the development of industry prices. Industry specific employment also affects female participation rates. The supply of labour is defined through source population and participation rates. Labour market tightness, real income and demographic variables influence participation rates. Population projections are generated by a demographic sub-model.

GDP by industry is the sum of the factor returns to labour, capital, and unincorporated business income. Factor returns to labour are defined for 96 industrial sectors at a level of detail consistent with the framework of the national accounts and the labour force survey. The wage bill responds positively to changes in the expected CPI, output per person, and average hours worked. Return to capital is defined for about 100 sectors plus some further disaggregation within mining and manufacturing. These equations can be interpreted as a sectoral pricing rule.

The financial sector provides the links between monetary aggregates, financial stocks, government debt and interest rates. Interest rates have the most important impact on the real sector of the model as a result of their utilization in the rental cost and return to capital equations.

3.2 Frequency of Forecasts

Updated forecasts are published periodically throughout the year, most usually on a quarterly basis.

3.3 Capability to Forecast Outputs by Specific Facilities Within Specific Industry Groups in Ontario (i.e., Ontario Applicability)

"A Regional-Industrial Model provides estimates for industries for each of Canada's provinces, and the two Territories, where the sum of provincial variables is equal to national totals. The sector detail is slightly smaller (121 industries for each province as compared to 159 for the national economy), but is the most highly disaggregated detail available in any modelling framework." [Informetrica (1991)]

4.0 OTHER WORTHWHILE RELATED INFORMATION

Some of the expenditure categories (and their stocks), or production and capital stock categories are currently used for direct linkage to emission considerations, as, for example, where considering emissions from the stock of owned vehicles, or emissions of NOX, SOX, etc. from relevant emitting sectors.

Output files are available in Lotus 1-2-3.

5.0 USEFULNESS

5.1 As A Source For Macro/Commodity Forecasts

The model has been widely used by numerous parties in government and industry to perform macroeconomic forecasts. It would be a useful source of macroeconomic forecasts. It is not a commodity forecasting model, however, except for those SICs which happen to be identified with a single commodity (such as iron ore and electricity). It also has a wealth of sectoral detail more generally.

5.2 For Forecasting Emissions, Effluents and Solid Wastes, and For Estimating the Impacts of Environmental Regulations

Informetrica currently maintains an air emissions satellite model. The model was developed by Informetrica as part of a larger study for Environment Canada. Developed using Informetrica software, it is currently maintained as part of the company's forecasts services function. In its present form, the model produces forecasts of seven different types of air pollutants emitted by 130 sources in Canada, based on TIM projections of gross output by industrial polluters. Emissions measures provided by the model include suspended particulates, SO_2, NO_x, CO, CO_2, total hydrocarbons and VOC's. Informetrica is currently considering the possibility of disaggregating this model by province.

THE WEFA CANADA MODEL [WCCM][14]

[The Wharton Economic Forecasting Associates Canada]

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

The model is used to produce short and long term forecasts, alternative scenarios, and to do policy analysis.

1.2 Main Users

The results are distributed to the firm's clients (large and medium sized corporations mainly) through its publications and at conferences.

1.3 Ownership

The WEFA Canada model [Wharton Canada Canadian Model - WCCM] is the property of WEFA Canada Inc. (Toronto).

1.4 Brief History of Development

The WEFA model has a confused parentage in that it is not actually directly related to the U.S. model of the same name. Rather it is based on work done by deBever on the Bank of Canada's SAM (Small Aggregate Model) in the mid to late 70's. On leaving the Bank, deBever established CHASE ECONOMETRICS, the immediate predecessor of WEFA, and built the CHASE model. When ownership of the firm changed in the mid 80's, the model was not unnaturally renamed. Considerable work has been done in recent times to rework and refine the model. Ernie Stokes, originally of the Conference Board, is its present minder.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

The WEFA Canada model describes a small open economy that produces and consumes domestic products and consumes foreign products. Due to the widely varying nature of Canadian products, an element of both price-taking and price-making behaviour is assumed for domestic producers. The foreign products are assumed to be imperfect substitutes for the domestic products. While there is significant detail in the model, its properties are essentially those of the one-sector macroeconomic models discussed in macroeconomic theory. The description of the model that follows is provided in the context of the latter theory. The model's economy is organized into four broad sectors. Firms employ capital and labour to produce a profit-maximizing output under a Cobb-Douglas constant-returns-to-scale technology

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and supply financial instruments. Households consume the domestic and foreign products, supply labour and demand financial assets under the assumption of utility maximization. Governments collect taxes, purchase the domestic and foreign products, product output and supply financial instruments. Foreigners purchase the domestic product, supply the foreign product and demand and supply financial instruments." [WEFA (1991)].

Key sectors can be described as follows:

"Consumer demand: derived from a modified version of the life-cycle model. The modifications include allowances for short-run disequilibrium effects - due to imperfect information and liquidity constraints - and changes in consumer confidence. A distinction is made in the model between durable and other types of consumer expenditures. Expenditures on durable goods are considered in a stock adjustment framework. Desired consumption of a particular consumption category is dependent on real wealth, normal or permanent labour and transfer income, the real interest rate and the category's relative price.

Residential investment demand: derived from the stock-flow model of the housing market. The desired stock of housing is dependent on those factors that determine the consumption of housing services, which are essentially the same as those discussed for consumption above.

Non-residential investment demand: based on firms' factor demands. The demand for capital and thus investment is derived from profit maximization. The long-run desired capital stock is dependent on expected output, the expected price of the product, and the expected user-cost of capital.

Government demand: essentially exogenous. For certain types of expenditures, it is also dependent on population growth. The model considers three major sources of government resources.

Exports: largely demand-determined in the model. As foreign demand, the relative price of foreign goods or the profitability of exporting increases, exports rise. Foreign demand is represented by industrial production or other final demand measures for Canada's major trading partners. The exchange rate plays an important role in the performance of exports through its impact on profitability or the relative price of foreign and domestic goods in a common currency. The demand for the domestic products is based on the above demands and that for imports. The demand for imports is a function of domestic economic activity and the relative cost of the domestic and foreign products. The model has a fully integrated supply side. By this is meant that there is a consistent integration of output, factor demands, output prices and factor prices. A production function is specified and corresponding factors demands are implied under an assumption of profit-maximizing behaviour on the part of the firms. These factor demands respond to output and factor prices. The latter, factor supplies and the production function together with demand determine output. A key assumption regarding the supply side of the model is that factors of production are quasi-fixed in nature due to adjustment costs - as a result of such things as career markets for labour - and the passage of time. Firms are assumed to maximize profits

subject to the production function. There are essentially four types of financial assets in the model: non-interest bearing money, interest bearing government bonds, equities and net claims on foreigners. Some additional detail is included for government bonds where a distinction is made between short-and long-term bonds, and for money where the monetary base, M1 and M2 are considered. Some credit aggregates are also included in the model. The interaction of the supply and demand for the financial assets for the various groups of economic agents in the model serves to determine the yields for these assets including the price of foreign exchange." [WEFA (1991)].

2.2 Estimation Period/Approach/Inputs

The model is estimated from post-war data, updated to the present i.e., to include the 1986 re-based national accounts.

It has about 900 equations, of which roughly 300 are stochastic. There are approximately 350 exogenous variables. (Important U.S. "driver" variables are obtained from the U.S. WEFA model).

The model is a quarterly one and uses a simulation and estimation package owned by WEFA.

2.3 Time Periods Over Which Forecasts Are Made

Being a quarterly model, forecasts are in principle available over any horizon from next quarter out to, for example, ten years or beyond.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

Variables forecast include the numerous categories of macro variables one would expect of a model of this type and size i.e.,income, consumption, investment, government expenditures, exports, imports, savings, taxes, inventories, monetary aggregates, interest rates, exchange rates, prices, housing, labour force/population/employment, wages, and so on.

3.2 Frequency of Forecasts

Short-term forecasts are issued quarterly, longer-term ones twice per year.

3.3 Capability To Forecast Outputs By Specific Facility Within Specific Industry Groups in Ontario (i.e., Ontario Applicability).

While WCCM itself, as a macro model, does not have the capability to directly generate forecasts to the level of specific facilities in Ontario, WEFA does have an Ontario macroeconomic model (The Ontario Macroeconometric Model - TOMM) which could be used in this regard. It is of recent vintage, is of virtually the same type of model as WCCM, and is described in some detail below.

In TOMM there are a number of Ontario product markets included (e.g., Agriculture, Manufacturing, etc.) of which seven are truly modelled). While these do not exactly match the industries listed by the Ministry, it would in principle be possible, via shift-share approaches, to approximate the relevant industry/facility "frame" the Ministry desires.

4.0 OTHER WORTHWHILE INFORMATION

It should not be surprising, given the origins of the model, that it has a reasonably well-developed financial sector, something of less relevance to environmental simulation concerns.

It should also be noted that a version of The WEFA model [WCCM] may be available for use on a PC.

5.0 USEFULNESS

5.1 As a Source for Macro and/or Commodity Forecasts

The WCCM model has been used by numerous parties in government and industry to perform macroeconomic forecasts. It would be a useful source of macroeconomic forecasts. It is not a commodity/industry forecasting model perse. The TOMM model is, however, more relevant because of its regional and small sectoral nature assuming its qualities are as stated by WEFA. Because of these characteristics it is likely the most regionally rich direct modelling available.

5.2 For Forecasting Emissions, Effluents and Solid Wastes, and for Estimating the Impacts of Environmental Regulations.

The same comments made for DRI apply to WEFA.

6.0 WEFA's ONTARIO MACROECONOMETRIC MODEL[15]

The Ontario model is a medium-sized annual macroeconometric model of the Ontario economy. The purpose of the model is to provide model users with a tool that will enable them to produce short-to long-term forecasts and impact studies for the Ontario economy. As a result, the model was designed with the goal that it would produce reasonable forecasts and possess appropriate simulation properties. While "goodness-of-fit" was an important aspect in model development, the attainment of appropriate simulation properties was the ultimate criterion.

[15] Information given here is based directly on that given by WEFA Canada.

The model describes a small open economy that produces a number of goods and services and consumes domestic and foreign goods and services. The domestic goods are produced by nine industries including the government. The foreign products are assumed to be imperfect substitutes for the domestically produced products. Domestic producers are assumed to have some market power in foreign and domestic markets. The domestic products refer to gross domestic product as factor cost. The foreign products are considered under one category, imports, because of the lack of data on provincial trade.

The economy is organized into four main sectors. Firms employ capital and labour to produce either cost-minimizing or profit-maximizing outputs under Cobb-Douglas constant-returns-to-scale technology and supply financial instruments. Households consume the domestic and foreign products, supply labour and demand financial assets under the assumption of utility maximization. Governments collect taxes, purchase the domestic and foreign products, produce output and supply financial instruments. Foreigners purchase the domestic products, supply the foreign product, and demand and supply financial instruments.

There are a number of markets in the model. These correspond to the domestic products, the labour market and financial markets. The product markets include: (1) Agriculture; (2) Other Primary; (3) Manufacturing; (4) Construction; (5) Transportation, Communication, Storage and Utilities; (6) Trade; (7) Finance, Insurance and Real Estate, FIRE; (8) Community, Business and Personal Services; and (9) Public Administration and Defence. Each of the above markets is concerned with the determination of demands, supplies and prices. There is no real market for the government product. The income generated from the supply of this product, nevertheless, and its impact on the economy, are fully integrated into the model.

14.0 U.S. Models

Introduction

Given the huge number of forecasting models in the United States, it was necessary to limit the scope of this component of the review. In consultation with the client, it was decided to focus upon forecasting activities related strictly to environmental issues.

Models were identified through a review of major economic journals and interviews with officials at the U.S. Environmental Protection Agency (E.P.A.). This approach yielded the following information.

- The Council on Environmental Quality, in conjunction with the E.P.A., commissions regular studies on the macroeconomic impact upon the U.S. economy. The first of these studies employed Chase Econometric Associates (since subsumed by W.E.F.A.). For the most recent, D.R.I. was retained. The major macroeconomic models of these private forecasting firms are described below.

- The economic impact analyses conducted for the E.P.A. contain forecasts of industry output. These studies were reviewed and their forecasting methods summarized.

- A detailed model of the U.S. copper industry was funded by the U.S. E.P.A. (Hartman, Bozdogan and Nadkarni).

- A long-term forecasting model which projects both emissions and the economic impacts of environmental regulations was commissioned by the EPA through, in part, Resources for the Future (Ridker and Watson).

- A 36-sector general equilibrium model, which concludes that engineering cost estimates diverge sharply from the full social costs of environmental regulation, was partially funded by the EPA (Hazilla and Kopp).

- A newly-developed general equilibrium model with 35 industry sectors is currently being used by the EPA (Jorgenson and Wilcoxen).

The last two models are particularly significant. It has long been argued that the dynamic effects of environment protection measures may be significantly more important than compliance expenditures. For example, firms may substitute away from pollution-intensive inputs and consumers may alter their consumption patterns if their disposable income or product prices change. General equilibrium models offer a tool with which to estimate these potentially substantial impacts.

We now turn to a detailed discussion of these models.

DRI/McGraw Hill Macroeconomic Model of the U.S. Economy

1.0 GENERAL INFORMATION

1.1 Purposes of the model

To generate forecasts of economic and financial indicators for use in strategic planning, capital budgeting, and policy planning.

1.2 Main Uses and Users

Fortune-500 companies, regulated industries, and government policy analysts.

1.3 Ownership

The DRI Macroeconomic Model of the U.S. Economy is the property of DRI/McGraw Hill, Inc., 24 Hartwell Avenue, Lexington, Massachusetts 02173.

1.4 Brief history of development

Founded in 1968 by Professor Otto Eckstein of Harvard University, DRI has grown into an organization of more than 1,000 employees, offering models for eleven nations (including Canada and the United States) and sixteen industries (including Steel, Energy, Chemicals, Pulp and Paper, Drilling, Commodities, and Utilities).

2.0 STRUCTURE OF THE MODEL

2.1 Key functional relationships

The model is based on a disaggregated elaboration and extension of the neoclassical *IS-LM* model. This annual macro model is coupled with an embedded input-output model to provide greater industry-level detail.

2.2 Degree of empirical research underlying the relationships and coefficients

The theoretical relationships underlying the model have been intensively scrutinized in the postwar period. However, because of differing theoretical approaches -- as exemplified by the New Classical (rational expectations), Monetarist, and New Keynesian schools -- no single model specification is universally accepted. Although in practice substantial consensus exists on use of the basic *IS-LM* framework, particular model specifications and the magnitudes of coefficients are still debated among economists.

The model's coefficients are estimated based on up to 46 observations of annual postwar data, although coefficients are often estimated based on more recent or more representative subsets of these data. As a rule, parameters are estimated based on data sets including no fewer than 20 observations. Coefficients can also be modified based on the user's judgment.

2.3 **Time period over which forecasts are made**

The model's long-term forecasts span twenty years.

2.4 **Time series or other data bases upon which the model draws**

The model draws on hundreds of time series of income, consumption, investment, government expenditures, exports, imports, savings, taxes, inventories, monetary aggregates, interest rates, exchange rates, prices, profits, population, housing, energy demand, labour force, employment, unemployment, wages, production costs, and production by industry. The source of most of this data is the U.S. federal government and private trade associations (see Section 4, Inputs).

DRI's U.S. central data bank, from which the model primarily draws, contains 24,000 time series.

3.0 OUTPUTS

3.1 **Economic or commodity forecasts provided by the model**

Variables forecasted include numerous categories of income, consumption, investment, government expenditures, exports, imports, savings, taxes, inventories, monetary aggregates, interest rates, exchange rates, prices, profits, population, housing, energy demand, labour force, employment, unemployment, wages, production costs, and production by industry.

Output is forecast for 60 SICs, in various combinations of 2- and 3-digit SIC codes, predominantly corresponding to the 2-digit level. This industry-level detail is generated using an input-output relationship in conjunction with the macro model's forecast of aggregate production.

3.2 **Links, if any, between the economic forecasts provided and forecasts of commodities**

The model does not generate commodity forecasts, but only forecasts of output and prices for industries at the 2-digit SIC level. These industry-level forecasts are generated by a macro model coupled with an embedded input-output model.

3.3 **Frequency of provision of forecasts**

Updated forecasts are published monthly.

3.4 **Degree of industry disaggregation provided (i.e., by 2-, 3-, or 4-digit SIC)**

Industrial production is disaggregated for 60 industrial categories, corresponding to approximately the 2-digit SIC level.

3.5 **Period over which forecasts are provided**

The model's long-term forecasts span twenty years.

3.6 **Specific product or intermediate product forecasts provided by the model (e.g., hot-rolled steel sheets or steel rails, raw pulp or fine papers)**

This model does not generate commodity forecasts, but only forecasts of output and prices for industries at the 2-digit SIC level. These industry-level forecasts are generated by a macro model coupled with an embedded input-output model. DRI also offers other, specialized-industry models, including Chemical, Commodities, Drilling, Energy, Pulp and Paper, Steel, and Utilities, among others.

3.7 **Capability of the model to forecast outputs of individual facilities in Ontario as opposed to sector demands**

At present, the model is estimated for the U.S. economy and does not forecast outputs of individual facilities in Ontario. Shift-share techniques could perhaps be used to estimate such outputs based on forecasts of U.S. production. However, a model of the Canadian and Ontario economies would provide a more direct basis for such forecasts than would a model of the U.S. economy.

4.0 INPUTS

4.1 **Exogenous variables**

Exogenous variables constitute 286 out of the model's 1260 total variables. Key exogenous variables include population, labour force, tax rates, depreciation rates, government employment, government purchases, money supply, and initial levels of business investment, corporate profits, exchange rates, exports, and imports.

4.2 **Sources used for data on these variables**

- Federal Reserve System Board of Governors
- Federal Home Loan Bank Board
- U.S. Department of Agriculture
- U.S. Department of Commerce, Bureau of the Census and Bureau of Economic Analysis
- U.S. Department of Defense

- U.S. Department of Energy
- U.S. Department of Labour, Bureau of Labour Statistics
- U.S. Department of the Treasury
- Private trade associations
- DRI estimates

5.0 ONTARIO APPLICABILITY

5.1 Extent to which the model has been used on Ontario industry

The model has not been used on Ontario industry.

5.2 Use of Ontario data in preparation of the forecasts

U.S. data, not Ontario data, were used in preparation of the forecasts.

5.3 For commodity models, a preliminary assessment of the similarity between the sector being modeled and the comparable Ontario sector

This model does not generate commodity forecasts, but only forecasts of output and prices for industries at the 2-digit SIC level. DRI also offers other, specialized-industry models, including Chemical, Commodities, Drilling, Energy, Pulp and Paper, Steel, and Utilities, among others.

6.0 USEFULNESS

6.1 Assessment of extent to which the model has been used in practice and views on its usefulness in doing macro-econometric and/or commodity forecasts

The model has been widely used by numerous parties in government and industry to perform macroeconomic forecasts. It would be useful source of macroeconomic forecasts. It is not a commodity forecasting model, however, except for those SICs which happen to be identified with a single commodity (such as iron ore and electricity).

6.2 Preliminary assessment of the potential usefulness of the model for forecasting emissions, effluents and solid wastes, and for estimating the impacts of environmental regulations

The model's high level of aggregation (2-digit SIC level) suggest that the model is not sufficiently articulated to accurately model pollution related to specific products or production technologies. Although a post-processor could be developed to translate the model's highly aggregated production forecasts into pollution-generation forecasts through accounting identities, the model's production functions do not incorporate pollution-generation variables as endogenous factors of production. Moreover, the input-output matrix embedded in the

model implies a single, static, average technology for each industry, instead of multiple technologies (with differing pollution rates) from which to choose.

The model could be modified to estimate the costs of environmental regulations through the diversion of investment to "non-productive" uses. Using a similar model, this was last done by DRI in 1981 for the Council on Environmental Quality (CEQ) and the U.S. EPA.

More difficult would be to modify the model to estimate the *benefits* of environmental regulations through such mechanisms as improved health and well-being. Because GNP measures certain "bads" such as pollution-related healthcare costs as "goods" and includes no direct measure of the stock of environmental quality or of well-being, a macroeconomic model of GNP may not be adequate to fully measure the benefits of environmental regulations.

Mark 9: The WEFA Group's U.S. Macroeconomic and Industry Model

1.0 GENERAL INFORMATION

1.1 Purposes of the Model

To generate forecasts of economic and financial indicators for use in strategic planning, capital budgeting, and policy planning.

1.2 Main Users

Fortune-500 companies, regulated industries, and government policy analysts.

1.3 Ownership

Mark 9 is the property of The WEFA Group.

1.4 Brief History of Development

The Wharton U.S. Quarterly Model of the U.S. economy was developed in 1963 by Professor Lawrence R. Klein and others at the University Pennsylvania, based in part on Michael Evans' thesis *A Postwar Quarterly Model of the U.S. Economy*. Dr. Klein won a Nobel Prize in economics in 1980 for his pioneering work in the field of econometrics. Michael Evans later became founder and president of Chase Econometric Associates, Inc., which merged with WEFA in 1986. The WEFA Group continues to up-date its modeling capabilities on a regular basis.

2.0 STRUCTURE OF THE MODEL

2.1 Key Functional Relationships

Mark 9 is a system of two sub-models: a core macro model and a satellite model providing industry detail. The core model contains 800 variables of which 287 are stochastic, 382 are identities and 131 are exogenous. The industrial model contains 477 variables of which 202 are stochastic, 199 are identities and 76 are exogenous variables supplied by the macro model.

The macro model is a quarterly econometric model of the U.S. economy. It is based on neo-Keynesian principles with some supply-side characteristics. The model is divided into nine sectors: (1) personal consumption, (2) fixed investment, (3) inventory investment, (4) government, (5) international trade, (6) the labour market, (7) wages and prices, (8) financial markets and (9) income. The macro model also includes fully specified housing, auto and energy sectors.

Several sectors include fairly detailed disaggregation. Fixed investment is composed of 10 different types of residential and non-residential investment. Weights derived from input-output tables are applied to components of spending to disaggregate output by 1-digit industry. These industry output variables determine labour and capital input used by each industry.

Producer prices are determined from input prices including unit labour costs. Producer prices drive various implicit price deflators, which in turn determine consumer price indices. However, pricing is endogenous since consumer price indices are also key determinants of the wage index (labour costs).

Key exogenous variables include fiscal policy levers, demographics, oil and food prices, the real exchange rate, inflation and foreign economic growth.

The industry satellite model (called the Industry Analysis Service model) is a combination input-output/stochastic model of activity in 117 U.S. industries. The model forecasts demand, production indices, shipments, value of production, inventories, prices, manhours, productivity, average hourly earnings, material cost and operating margin for 73 manufacturing industries. For an additional 44 non-manufacturing industries, value of production, prices, manhours, and productivity are forecast.

The macro and industry models are linked by converting the expenditure components of GDP from the macro model into industrial deliveries to final demand. Once final demand is calculated, standard input-output techniques are used to derive industrial output by sector.

2.2 Estimation Period/Approach/Inputs

The macro model uses a wide variety of data from many sources. For the most part, data used to estimate stochastic equations are post-war, seasonally adjusted, quarterly data from various government agencies. Some monthly data are also employed, especially in the industry satellite model.

Stochastic equations were estimated using ordinary least squares.

3.0 OUTPUTS

3.1 Economic and/or Commodity Forecasts

The model generates baseline short-term forecasts for two scenarios. The first scenario captures economic trends, while the second focuses on business cycles. Forecasts are made for a wide variety of industry indicators, including demand, production indices, shipments, value of production, inventories, prices, manhours, productivity, average hourly earnings, material cost and operating margin for 73 manufacturing industries.

3.2 Frequency of Forecasts

Three-year and ten-year forecasts are updated monthly. Twenty-five-year forecasts are updated quarterly.

3.3 Time Period Over Which Forecasts Are Made

Three forecasts are produced regularly for time periods of three, ten and twenty-five years.

3.4 Capability to Forecast Outputs by Specific Facilities Within Specific Industry Groups in Ontario (i.e., Ontario applicability)

The model forecasts U.S. economic activity. The WEFA Group does include Canadian modeling capabilities discussed elsewhere in this report.

4.0 OTHER WORTHWHILE INFORMATION

WEFA also houses an energy satellite model for the U.S. Selected variables for five different fuel types are forecast.

5.0 USEFULNESS

5.1 As a Source for Macro/Commodity Forecasts

The model's primary purpose is to provide macroeconomic forecasts and policy simulations. It has been widely used by both public and private clients. Although the model is not specifically a commodity forecasting model, it does predict variables, including value of production, for 73 manufacturing industries.

5.2 For Forecasting Emissions, Effluents and Solid Wastes, and for Estimating the Impacts of Environmental Regulations

One of The WEFA Group's predecessors, Chase Econometrics, performed several simulations for the Council on Environmental Quality and the Environmental Protection Agency. The macroeconomic impacts of EPA regulations were estimated by diverting investment towards "non-productive," pollution control activities.

The model is not currently capable of forecasting emissions, effluents or solid wastes.

Forecasting in the EPA Economic Impact Analyses

Proposed EPA regulations undergo examination to determine the economic impact they will have upon the industry to be regulated. One component of many of these economic impact analyses is a projection of industrial production.

A cross-section of these studies were reviewed to determine of there forecasting techniques might be of use to the Ministry. The generic information shell used elsewhere does not facilitate exposition of the results of this review. Therefore, we deviate from its structure and discuss the results under two headings: Forecasting Techniques and Usefulness to the Ministry.

Forecasting Techniques

A diverse set of forecasting methods were employed. Depending upon the industrial sector, they ranged from the most simplest assumptions and ad hoc microeconomic analysis to large-scale forecasting models. Since no patterns emerged, we provide a number of examples.

- NonFerrous Metals Industry: assumed that the most recent annual production levels would continue.
- Placer Gold Mining Industry: constructed an industry supply curve by plotting plants' historical unit operating costs against historical production. The study then predicted unit costs with and without the environmental regulation and derived future production from these projections.
- Inorganic Chemical Industry: a base year production level was subjected to an estimated supply elasticity and a forecast of output prices.
- Iron and Steel Industry: assumed that iron and steel production would follow the same growth patterns as a DRI forecast of auto production.
- Offshore Oil and Gas Industry: employed an in-house model of the Department of Energy.

Usefulness to the Ministry

The techniques obviously vary greatly in their degree of rigour. Obviously some techniques are last resorts necessitated by data or resource constraints. Some techniques used to estimate supply curves, while seemingly more rigorous, are not defensible on theoretical grounds. Since the forecasting methods range so drastically, these studies must be reviewed on an individual basis.

Hartman, Bozdogan and Nadkarni (1979)

1. GENERAL INFORMATION

1.1 Purposes of the model

To estimate the costs of environmental regulations on the copper industry.

1.2 Main uses and users

The U.S. EPA, government policy analysts, copper-industry decision-makers and representatives.

1.3 Ownership

Performed by Raymond Hartman (Boston University and MIT) and Kirkor Bozdogan and Ravindra Nadkarni (Arthur D. Little). Funded by the U.S. EPA under contract no. 68-01-2842.

1.4 Brief history of development

Results published by Hartman, Bozdogan, and Nadkarni in "The Economic Impacts of Environmental Regulations on the U.S. Copper Industry," in *The Bell Journal of Economics*, Autumn 1979, vol. 10, no. 2. The model is similar to efforts by Charles Rivers Associates (1970, 1973, 1977) for the U.S. General Services Administration.

2.0 STRUCTURE OF THE MODEL

2.1 Key functional relationships

The model consists of a market-clearing module (featuring imperfect competitive pricing); a financial module (estimating profitability and expectations of future profitability); and an investment module (for both capacity expansion and replacement).

2.2 Degree of empirical research underlying the relationships and coefficients

Detailed regression results are presented. It appears that Arthur D. Little had sufficient detailed data to estimate industry cost and production functions.

2.3 Time period over which forecasts are made

The forecast period ranges from 1974 to 1987.

2.4 **Time series or other data bases upon which the model draws**

For the copper industry: fixed costs, variables costs, sales, production, investment, exports, and imports.

3.0 OUTPUTS

3.1 **Economic or commodity forecasts provided by the model**

The model estimates the impacts of alternative environmental regulations on the U.S. copper industry.

3.2 **Links, if any, between the economic forecasts provided and forecasts of commodities**

Forecasts of underlying economic conditions are exogenous to the model.

3.3 **Frequency of provision of forecasts**

The 1979 journal article provides only a single forecast. Updates of the model might be available based on negotiations with the authors or the U.S. EPA.

3.4 **Degree of industry disaggregation provided (i.e., by 2-, 3-, or 4-digit SIC)**

The model is estimated for the U.S. copper industry (related SIC codes include 3331, 3340, 3351, 3362).

3.5 **Period over which forecasts are provided**

The forecast period ranges from 1974 to 1987.

3.6 **Specific product or intermediate product forecasts provided by the model (e.g., hot-rolled steel sheets or steel rails, raw pulp or fine papers)**

The model estimates impacts of alternative environmental regulations on copper, including primary refined, secondary refined, and unrefined scrap.

3.7 **Capability of the model to forecast outputs of individual facilities in Ontario as opposed to sector demands**

At present, the model is estimated for the U.S. economy. Re-specification (further disaggregation) and re-estimation would be required to forecast outputs of individual facilities in Ontario.

4.0 INPUTS

4.1 Exogenous variables

Mining and milling investment is treated as exogenous; smelting and refining investment is treated as endogenous.

4.2 Sources used for data on these variables

- The Copper Development Association (CDA)
- The American Bureau of Metal Statistics (ABMS)

5.0 ONTARIO APPLICABILITY

5.1 Extent to which the model has been used on Ontario industry

The model was estimated for the U.S., and has not been used on Ontario industry.

5.2 Use of Ontario data in preparation of the forecasts

Ontario data were not used in preparing the forecasts.

5.3 For commodity models, a preliminary assessment of the similarity between the sector being modeled and the comparable Ontario sector

It appears that the model could be re-estimated for use in Ontario.

6.0 USEFULNESS

6.1 Assessment of extent to which the model has been used in practice and views on its usefulness in doing macro-econometric and/or commodity forecasts

The purpose of the model is not so much to provide a base commodity forecast for copper as to estimate the impacts of alternative environmental regulations on the U.S. copper industry.

6.2 Preliminary assessment of the potential usefulness of the model for forecasting emissions, effluents and solid wastes, and for estimating the impacts of environmental regulations

The model appears to be useful for estimating costs of environmental regulations to the copper industry. In its current form, it does not forecast emissions or estimate benefits.

Hazilla and Kopp (1990)

1. GENERAL INFORMATION

1.1 Purposes of the model

To estimate the social costs of environmental regulations; and to evaluate whether they differ significantly from private costs as commonly used in cost-benefit analysis.

1.2 Main uses and users

Government policy analysts.

1.3 Ownership

Performed by Michael Hazilla (American University) and Raymond Kopp (Resources for the Future). Funded in part by the U.S. EPA Office of Air Quality, under contract no. 68-02-35-82.

1.4 Brief history of development

Results published by Hazilla and Kopp in "Social Cost of Environmental Quality Regulations: A General Equilibrium Analysis," in the *Journal of Political Economy*, 1990, vol. 98, no. 4.

2. STRUCTURE OF THE MODEL

2.1 Key functional relationships

The model is a dynamic general equilibrium model designed to estimate social welfare, allowing for substitutions in consumption and between production technologies. Production is modeled using translog cost functions; consumption is modeled using translog utility functions. Social welfare is measured using the Hicksian notion of "compensating variation" (the additional income required to compensate individuals for their welfare loss associated with a change in regulations).

2.2 Degree of empirical research underlying the relationships and coefficients

Numerous general equilibrium models have been developed in the postwar period.

2.3 Time period over which forecasts are made

The forecast period ranges from 1974 to 1987.

2.4 **Time series or other data bases upon which the model draws**

The model's coefficients are estimated using time series that range from 1958-1974, predating the Clean Air and Clean Water acts. The objective is to characterize the base case economy using preregulation technologies.

3.0 OUTPUTS

3.1 **Economic or commodity forecasts provided by the model**

The model "backcasts" (generates estimated values over a historical period) the changes in output and employment by environment-regulation scenario. These estimates are not commodity-specific, but for 36 industrial sectors at approximately the 2-digit SIC level.

3.2 **Links, if any, between the economic forecasts provided and forecasts of commodities**

The model does not generate commodity forecasts.

3.3 **Frequency of provision of forecasts**

The 1990 journal article provides only a single forecast. Updates of the model might be available based on negotiations with Hazilla and Kopp, or the EPA.

3.4 **Degree of industry disaggregation provided (i.e., by 2-, 3-, or 4-digit SIC)**

The model is disaggregated into 36 producing sectors, corresponding to 2-digit SIC codes.

3.5 **Period over which forecasts are provided**

The model "backcasts" (forecasts over a historical period) from 1975 to 1990.

3.6 **Specific product or intermediate product forecasts provided by the model (e.g., hot-rolled steel sheets or steel rails, raw pulp or fine papers)**

The model does not provide specific product forecasts.

3.7 **Capability of the model to forecast outputs of individual facilities in Ontario as opposed to sector demands**

The model is estimated for the U.S. economy at the 2-digit SIC level. Extensive re-specification (disaggregation) and re-estimation would be required to forecast outputs of individual facilities in Ontario.

4.0 INPUTS

4.1 Exogenous variables

Population, government expenditures, government budget deficits, environmental regulations.

4.2 Sources used for data on these variables

Historical values (1970-1985) and DRI forecasts (1986-1990).

5.0 ONTARIO APPLICABILITY

5.1 Extent to which the model has been used on Ontario industry

The model was estimated for the U.S., and has not been used on Ontario industry.

5.2 Use of Ontario data in preparation of the forecasts

Ontario data were not used in preparing the forecasts.

5.3 For commodity models, a preliminary assessment of the similarity between the sector being modeled and the comparable Ontario sector

Not a commodity-forecasting model.

6.0 USEFULNESS

6.1 Assessment of extent to which the model has been used in practice and views on its usefulness in doing macro-econometric and/or commodity forecasts

The model has been used only for "backcasts" (generation of estimated values for historical years), but would appear useful for the generation of macro-economic forecasts. The general-equilibrium approach also appears useful for the generation of commodity forecasts, although the model's current level of detail is not commodity-specific. Re-specification (disaggregation) and re-estimation would be required.

6.2 Preliminary assessment of the potential usefulness of the model for forecasting emissions, effluents and solid wastes, and for estimating the impacts of environmental regulations

The model appears to be useful for estimating social costs of environmental regulations. In its current form, it does not forecast emissions or estimate benefits.

Jorgenson and Wilcoxen (1990)

1.0 GENERAL INFORMATION

1.1 Purposes of the model

To estimate the costs of pollution controls by simulating the growth of the U.S. economy with and without regulation.

1.2 Main uses and users

Scholarly article without reference to any government grant, although Professor Jorgenson collaborates with the U.S. EPA.

1.3 Ownership

Intellectual property of Dale Jorgenson and Peter Wilcoxen of Harvard University (scholarly article without reference to any government grant).

1.4 Brief history of development

Published in the *RAND Journal of Economics*, Vol. 21, No. 2, Summer 1990.

2.0 STRUCTURE OF THE MODEL

2.1 Key functional relationships

The model goes beyond fixed-coefficient input-output models (which rule out by assumption the possibility of substitution between factors of production) by using an intertemporal econometric approach to make inputs substitutable and to make productivity growth by industry endogenous. Using this approach, the input-output coefficients are determined endogenously through time.

2.2 Degree of empirical research underlying the relationships and coefficients

This methodology was originated by Jorgenson and Fraumeni (1981), Jorgenson, Lau, and Stoker (1982), constructed by Jorgenson and Slesnick (1987), and analyzed by Hogan and Jorgenson (1990).

2.3 Time period over which forecasts are made

The model's projections span 60 years, to the year 2050.

2.4 **Time series or other data bases upon which the model draws**

Data on interindustry transactions are based on input-output tables for the U.S. from the Commerce Department's Bureau of Economic Analysis (1984).

3.0 OUTPUTS

3.1 **Economic or commodity forecasts provided by the model**

The model provides detail for 35 industries and 35 commodity groups, which correspond to the primary product of each the 35 industries.

3.2 **Links, if any, between the economic forecasts provided and forecasts of commodities**

The 35 commodity groups are econometrically linked to the output forecasts of the 35 industries through variable-coefficient input-output tables.

3.3 **Frequency of provision of forecasts**

The 1990 journal article provides only a single forecast. Updates of the model might be available based on negotiation with Professors Jorgenson and Wilcoxen.

3.4 **Degree of industry disaggregation provided (i.e., by 2-, 3-, or 4-digit SIC)**

The 35 industries correspond to approximately the 1- to 2-digit SIC level.

3.5 **Period over which forecasts are provided**

The model's projections span 60 years, to the year 2050.

3.6 **Specific product or intermediate product forecasts provided by the model (e.g., hot-rolled steel sheets or steel rails, raw pulp or fine papers)**

The model provides forecasts for 35 commodity groups, corresponding to the primary product of the 35 industries.

3.7 **Capability of the model to forecast outputs of individual facilities in Ontario as opposed to sector demands**

At present, the model is estimated for the U.S. economy and does not forecast outputs of individual facilities in Ontario. Shift-share techniques could perhaps be used to estimate such outputs based on forecasts of U.S. production. However, a model of the Canadian and Ontario economies would provide a more direct basis for such forecasts than would a model of the U.S. economy.

4.0 INPUTS

4.1 Exogenous variables

Key exogenous variables include investment in pollution-control equipment, import prices, household time budget, government deficit or surplus, current account balance, government spending, rest-of-world demand, population, and educational attainment.

4.2 Sources used for data on these variables

Data on interindustry transactions are based on input-output tables for the U.S. from the Commerce Department's Bureau of Economic Analysis (BEA, 1984). U.S. national income and product accounts are also from the BEA. Data on capital and labour are based on those of Jorgenson, Gollop, and Fraumeni (1987).

5.0 ONTARIO APPLICABILITY

5.1 Extent to which the model has been used on Ontario industry

The model was estimated for the U.S., and has not been used on Ontario industry.

5.2 Use of Ontario data in preparation of the forecasts

Ontario data were not used in preparing the forecasts.

5.3 For commodity models, a preliminary assessment of the similarity between the sector being modeled and the comparable Ontario sector

The model reportedly provides detail only for commodity groups, not specific commodities. The composition of these commodity groups and their similarity to the comparable Ontario sectors are not detailed in the journal article.

6.0 USEFULNESS

6.1 Assessment of extent to which the model has been used in practice and views on its usefulness in doing macro-econometric and/or commodity forecasts

The model appears to be a useful source of macroeconomic forecasts, although its industry-level detail is disaggregated to only 35 industrial categories. It also appears to be a useful source of commodity forecasts, although the specific composition of its 35 commodity groups is not detailed in the journal article.

6.2 **Preliminary assessment of the potential usefulness of the model for forecasting emissions, effluents and solid wastes, and for estimating the impacts of environmental regulations**

The model is designed to estimate the costs of environmental regulations through the diversion of investment to "non-productive" uses. The model appears useful for this purpose.

Although the model includes the costs of pollution controls, it does not directly incorporate pollution-generation variables. Moreover, its high level of aggregation suggests that it is not sufficiently articulated to accurately model pollution related to specific products or production technologies. Therefore, it does not appear useful for forecasting pollution generation.

This model is not designed to estimate the *benefits* of environmental regulations through such mechanisms as improved health and well-being. It does not appear that the model would be useful for this purpose.

Strategic Environmental Assessment System/Resources for the Future (SEAS/RFF)[16]

1.0 GENERAL INFORMATION

1.1 Purposes of the model

To estimate the cost and welfare impacts of alternative environmental regulations.

The model begins with assumed projections of national economic activity, pollution abatement costs, and pollutant generation; assigns pollutants from point- and non-point sources to regions; translates pollutant generation into ambient air and water pollutant concentrations by region; and estimates air and water pollution damage as a function of ambient conditions by region.

1.2 Main uses and users

Environmental-association and governmental policy analysts.

1.3 Ownership

Intellectual property of Ridker, Wilson, and Resources for the Future (no reference is made to a government grant).

1.4 Brief history of development

Developed by Ronald Ridker at the World Bank (while on leave from Resources for the Future) in collaboration with William Watson of the U.S. Geological Survey. The national economic activity projections used in the model are derived from the SEAS/RFF, the core of which is a dynamic input-output model of the U.S. economy, which was developed in 1974 by Clopper Almon at the University of Maryland.

2. STRUCTURE OF THE MODEL

2.1 Key functional relationships

The model includes side equations dealing with product and technology mixes within these sectors, in order to provide more detail to project pollution levels and abatement costs. Six main technology substitutions are emphasized, e.g., the substitution of concrete for lumber and

[16] Ridker, R. and W. Watson (1981) "Long-Run Effects of Environmental Regulation" in the Natural Resources Journal 21:3 (July):565-87.

steel in construction. A submodel estimates the investment and O&M costs associated with pollution control by abatement sector. Net emissions are calculated and distributed via dispersion models. Damage costs are estimated as a function of per capita exposures. Assumes that aggregate savings will increase as needed to finance all abatement and productive investment.

2.2 **Degree of empirical research underlying the relationships and coefficients**

Dispersion, exposure, dose-response, and damages are all profoundly difficult to estimate. While the estimates in the model presumably reflect assumptions based on the best available research, accuracy in measuring absolute magnitudes cannot be expected. Instead, the model is useful in assessing relative levels of magnitudes in order to compare the effects of certain kinds of environmental policies.

2.3 **Time period over which forecasts are made**

The model's projections extend from 1975 to the year 2025.

2.4 **Time series or other data bases upon which the model draws**

Assumes projected values of population and national economic activity variables (population, labour force, GNP, consumption, investment, government expenditures, net exports). Abatement costs, point- and non-point source gross pollution coefficients, percent of pollution controlled by scenario, pollution dispersion factors, generation-to-ambient concentration factors, and damage (dose-response) factors are also assumed or estimated based on special studies.

3.0 OUTPUTS

3.1 **Economic or commodity forecasts provided by the model**

The model does not generate but assumes its base economic forecast and generates no commodity forecasts. Instead, the model estimates the *changes* in national economic activity, pollution, and damage (welfare) by alternative environmental-regulation scenario.

3.2 **Links, if any, between the economic forecasts provided and forecasts of commodities**

The model generates no commodity forecasts.

3.3 **Frequency of provision of forecasts**

Most recent results were published in July 1981. Updates would depend on negotiation with RFF.

3.4 **Degree of industry disaggregation provided (i.e., by 2-, 3-, or 4-digit SIC)**

The model includes 185 sectors corresponding predominantly to approximately the 3-digit SIC level. In addition, the model included 364 side equations dealing with product and technology mixes within these sectors, in order to provide more detail to project pollution levels and abatement costs. A submodel estimates the investment and O&M costs associated with pollution control for 131 abatement sectors.

3.5 **Period over which forecasts are provided**

The model's projections extend from 1975 to the year 2025.

3.6 **Specific product or intermediate product forecasts provided by the model (e.g., hot-rolled steel sheets or steel rails, raw pulp or fine papers)**

A dynamic input-output model provides industry detail; however, the purpose of the model is not to produce base forecasts but to estimate the impacts of alternative scenarios.

3.7 **Capability of the model to forecast outputs of individual facilities in Ontario as opposed to sector demands**

The model is estimated for the U.S. economy at approximately the 3-digit SIC level. Re-specification and re-estimation would be required to forecast outputs of individual facilities in Ontario.

4.0 INPUTS

4.1 **Exogenous variables**

Projected values of population and national economic activity variables (population, labour force, GNP, consumption, investment, government expenditures, net exports). Abatement costs, point- and non-point source emissions rates, pollution dispersion factors, generation-to-ambient concentration factors, and damage (dose-response) factors are also assumed or only roughly estimated.

4.2 **Sources used for data on these variables**

National economic activity estimates are derived using the national components of the SEAS/RFF modeling systems.

5.0 ONTARIO APPLICABILITY

5.1 Extent to which the model has been used on Ontario industry

The model was estimated for the U.S., and has not been used on Ontario industry.

5.2 Use of Ontario data in preparation of the forecasts

Ontario data were not used in preparing the forecasts.

5.3 For commodity models, a preliminary assessment of the similarity between the sector being modeled and the comparable Ontario sector

Not a *base* commodity forecasting model, but may be useful for estimating changes in commodity forecasts by environmental-regulation scenario.

6.0 USEFULNESS

6.1 Assessment of extent to which the model has been used in practice and views on its usefulness in doing macro-econometric and/or commodity forecasts

The model is not a *base* forecasting model, but its approach appears useful for estimating *changes* in commodity forecasts by environmental-regulation scenario. Because the model assumes that savings will increase as necessary to meet all investment requirements, it appears less useful for estimating changes to macro-economic forecasts.

6.2 Preliminary assessment of the potential usefulness of the model for forecasting emissions, effluents and solid wastes, and for estimating the impacts of environmental regulations

Because many important variables in the model are exogenous or assumed, the model does not appear useful as a base forecasting model. Its usefulness is as a model to estimate changes in emissions, costs, and benefits by alternative environmental-regulation scenarios.

Appendix A

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Appendix B Contact List

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Appendix C

Industrial Detail of Canadian Macroeconomic Models

Appendix C Industrial Detail of Canadian Macroeconomic Models

DATA RESOURCES/McGRAW-HILL MODEL (DRI)

1.0 Exact Industry Breakdown and How Calculated for Models of the National Economy

- industrial output related to any macro forecast is calculated for 43 industries at the Canadian 1980 SIC 2-digit level and includes 10 industry aggregations.

1980 SIC CODES *	INDUSTRY (SNA CODE)
O1,02	Agriculture (SOI)
O3	Fishing & Trapping (S02)
O4,05	Forestry (SO3)
O61	Metal Mining (SO4MO4LOO4-006)
O62,063,O8	Non-Metal Mining (SO4MO4LOO7-O1O.SO4MO6)
07	Mineral Fuels (SO4MO5)
09	Services Related to Mineral Extraction (SO4MO7) Total Manufacturing (SO5) Non-durable Manufacturing (G36)
10,11,12	Food, Beverages & Tobacco (SO5MO8-10)
15,16	Plastics, Rubber (SO5M11-12)
17,18,19,24	Textiles, clothing & leater (SO5M13-15)
27	Pulp and Paper (SO5M18)
28	Printing & Publishing (SO5M19)
36	Petroleum & coal (SO5M26)
37	Chemical Products (SO5M27) Durable Manufacturing (G37)
25	Wood Products (SO5M16)
26	Furniture & Fixtures (SO5M17)
29	Primary Metals (SO5M20)
30	Metal Fabricating (SO5M21)
31	Machinery (SO5M22)
32	Trasportation Equipment (SO5M23)
33	Electrical Products (SO5M24)

1980 SIC CODES *	INDUSTRY (SNA CODE)
35	Non-Metallic Mineral Prod. (SO5M25)
39	Miscellaneous Manufacturing (SO5M28)
40,41,42,44	Construction (SO6)
45,46,47	Transportation & Storage (SO7)
48	Communications (SO8)
491	Electrical Power (SO9M34L132)
492,493,494	Utilities Excl. Electricity (SO9M34L133-134)
50-69	Wholesale & Retail Trade (S10-11)
70-76	Finance, Insurance & Real Estate (S12)
77,85,86,91,92,96,97,98,99	Community, Business & Personal SRV. (S13) Non-Bus. Mining (S17) Non-Bus. Manufacturing (S18) Non-Bus. Forestry (S19) Non-Bus. Transportation (S20) Non-Bus. Communication (S21) Non-Bus. Water Systems (S22) Non-Bus. Finance, Insurance & Real Estate(S23) Non-Bus. Government Services (S24) Non-Bus. Community & Personal SRV. (S25)
	Total Business Sector (G27) Business-Goods Prod. (G28) Business-Services Prod. (G29) Total Non-Bus. Sector (G30) Non-Bus. Goods Prod. (G31) Non-Bus. Services Prod. (G32) Total Goods Production Industry (G33) Total Services Producing Industry (G34) Industrial Production (G35) Total RDP at Factor Cost (G26)

* 1980 SIC codes are only approximate since they include both the business and non business sectors. The data used in DRI's Industry Model uses System of National Accounts (SNA) definitions. For more information on SNA difinitions and their relationship with the 1980 SIC, please refer to Statistics Canada's Gross Domestic Product by Industry, catalogue 15-001 (June issue).

- real output for each industry is generated from total demand in the macro model using an input-output block of 34 industries which incorporates STATCAN I/O matrices.

2.0 Exact Industry Breakdown, and How Calculated, for Models of the Ontario Economy

- DRI has a regional model for Canada, one region of which it covers being Ontario. Since this model "runs off" the Macro and Industry models, industrial output for the Ontario region is available for the same 2-digit SIC code industries and aggregations as detailed in 1.0 above.

- real output for each industry in Ontario "runs off" the Macro and Industry model forecasts i.e., aggregate output is solved in the Macro model, then split off to industries using the I/O tables, and then "regionalized" by industry using a slightly more complicated approach than simple historical share of that industry's totals (it is based on a weighted average of shares of output-determining variables derived from a regression model). DRI describes the process as follows:

> "Although the regional model does ensure that national totals are always maintained, it is not a simple sharing of the national totals. In order to include a "bottom-up" framework, the model includes two equations for each concept and region. The first of the two equations is an estimated behaviourial relationship that captures the various factors affecting a particular variable in a particular region. The second equation ensures that each of the provincial variables sum to the national totals while using the relative weighting determined in the first equation. There is also a considerable number of inter-provincial links in the model, so that economic activity in one part of the country is related to and affected by economic activity elsewhere." [DRI (1991)].

FEDERAL GOVERNMENT/FOCUS/MACE MODELS

I. Federal Government Models

- only CANDIDE has any industry detail (and what detail!), and it is no longer up and running. Thus it is of little import to discuss breakdowns further.

II. FOCUS (U. of T Policy Institute)

- FOCUS does not forecast individual sectoral, or commodity, output or prices.

III. MACE (U.B.C., Prof. J. Helliwell)

- MACE is primarily an aggregate model designed to study energy impacts. While it is broken down into sectors, there are only two - energy and everything else. This is of little use to the Ministry as its purposes are understood. Recall also, it is an annual model with no regional breakdowns.

MTFM [MED. TERM FORECASTING MODEL] AND THE PC ONTARIO MODEL - THE CONFERENCE BOARD

1.0 Exact Industry Breakdown, and How Calculated, for Models of the National Economy

- output, employment, average weekly wages and average hourly earnings are modelled in the MTFM for 40 industries. These industries are:

Industry GDP	SIC Code (major group)
Agriculture	010, 020
Forestry	040, 050
Fishing and Trapping	030
Metal Mining	061
Non-Metal Mining	062, 080
Mineral Fuels	063, 070
Services Incidental to Mining	090
Food and Beverage	100, 110
Tobacco	120
Rubber and Plastics	150, 160
Leather	170
Textile	180, 190
Clothing	240
Wood Industries	250
Furniture	260
Paper and Allied	270
Printing and Publishing	280
Primary Metals	290
Metal Fabricating	300
Machinery	310
Transportation Equipment	320
Electrical Products	330
Non-Metallic Industries	350
Petroleum and Coal	360
Chemicals	370
Miscellaneous Manufacturing	390
Construction	400, 410, 420, 440
Transportation and Storage	450, 460, 470
Communication	480
Utilities	490
Wholesale Trade	500, 510, 520, 530, 540, 550, 560, 570, 590
Retail Trade	600, 610, 630, 640, 650, 690
Finance Insurance and Real Estate	700, 710, 720, 730, 740, 750, 760
Imputed Rent	Not Applicable
Amusement and Recreation	960
Business Services	770
Accommodation and Food	910, 920
Personal Services and Miscellaneous	970, 980, 990

Non-Commercial Services	850, 860
Public Administration and Defence	810, 820, 830, 840

- real output for each industry is generated from total output using recent input-output matrices from STATCAN. There are no industry-level production functions.

2.0 Exact Industry Breakdown, and How Calculated, for Models of the Ontario Economy

- the Conference Board can/does obtain industry breakdowns for the Ontario Economy in one of two different ways a) using MTFM and its Provinces/Territories Model and b) using PC Ontario: a new stand-alone model of the Ontario economy.

- under a), real output is solve in the national model, then split off to industries using the I/O procedure alluded to above in 1.0.

- under b), the new stand-alone PC Ontario model, while it is not exactly clear from the organization's material, it would appear that output is determined simultaneously for the more than 30 industry GDP disaggregations. Details on the exact industry breakdowns are as follows [N.B., real gross domestic product at factor prices (1986$)]:

Agriculture
Forestry
Fishing and Trapping
Mining
- Metals
- Non-Metals
- Mineral Fuels
- Services Incidental to Mining

Manufacturing
- Food and Beverages
- Rubber and Plastics
- Textile, Knitting and Clothing
- Wood Products
- Furniture
- Pulp and Paper
- Printing
- Primary Metals
- Metal Fabricating
- Machinery
- Transportation Equipment
- Electrical Products
- Non-Metallic Minerals
- Petroleum and Coal
- Chemicals
- Miscellaneous Manufacturing

Construction
Utilities
Transportation, Communication, and Storage

Trade
- Retail Trade
- Wholesale Trade

Finance, Insurance and Real Estate
- Imputed Rent
- Other Finance Insurance and Real Estate

Community, Business and Personal Services
- Commercial Services
- Non-Commercial Services

Public Administration and Defence

Total GDP

THE INFORMETRICA MODEL [TIM]

1.0 Exact Industry Breakdown, and How Calculated, for Models of the National Economy

- TIM is essentially a neo-Keynesian macro model with a large imbedded I/O model which integrates the expenditure and output sides of the larger model.

The following tabulates the level of industry detail available in the model, and for which projections are currently made (to the year 2020) or for which the detail can be used of impact studies. A finer level of detail does exist in the model database, but projections and endogenous model reactions are limited to the following.

Mnemonic	Description
TLB	Business
AGR	Agriculture and related service
FSH	Fishing and trapping
FOR	Logging and forestry
RES	Mining-total extraction
RET	Mining (metals and nonmetal)
RMT	Metal mining
RMG	Gold
RMI	Iron Ore
RMO	Other
RNT	Nonmetal mining and coal
RNX	Nonmetal mining
RNA	Asbestos
RNS	Salt
RNO	Other
RNC	Coal
RPG	Crude petroleum and natural gas
RQS	Quarry and sand pit
RSV	Mining services
MAT	Manufacturing
MFT	Food Products, Total (Ex Bev)
MFA	Meat and Poultry Products
MFF	Fish
MFV	Fruit and vegetables
MFD	Dairy
MFG	Feed
MFX	Miscellaneous
MBV	Beverages
MBS	Soft drink
MBH	Alcoholic beverages
MTB	Tobacco
MRB	Rubber
MPL	Plastic
MLT	Leather
MXT	Primary textile and textile

MGL	Garments and Clothing
MWD	Wood
MFU	Furniture
MPT	Paper and Allied
MP1	Pulp and Paper
MP2	Paper Converters
MPR	Printing and Publishing
MPM	Primary Metal
MPF	Iron and Steel
MPN	Non-Ferrous
MPX	Smelting
MPE	Extruding, Casting
MPA	Aluminum
MPC	Copper Alloys
MPZ	Other
MMF	Metal Fabrication
MMT	Machinery
MMA	Agriculture
MMX	Non-agriculture
MTT	Transportation Equipment
MTA	Aircraft etc.
MTV	Motor Vehicles
MTC	Car and Truck Assembly
MTH	Truck and Bus Bodies
MTP	Parts and Accessories
MTZ	Railroad Rolling Stock and Miscl
MTR	Rolling Stock
MTX	Miscellaneous
MTS	Shipbuilding
MET	Electrical Equipment
MEA	Appliances
MEH	Hi tech Communications Equipment
MEC	Computers
MEB	Batteries
MEW	Wire
MEO	Other
MEX	Other Miscellaneous
MNT	Non-Metallic Minerals
MNC	Cement and Clay Products
MNG	Glass
MRP	Petroleum and Coal Refining
MCT	Chemicals
MCI	Industrial
MCO	Non-Industrial
MOT	Other Miscellaneous
CON	Construction
CRP	Repair construction
CRS	Residential construction

CST	Construction-nonresidential buildings
CRH	Highway and airstrips
CGO	Gas and oil facility
CDI	Dams and irrigation projects
CRA	Rail and telephone, telegraph
COE	Other engineering
COX	Other activity
TSP	Transportation and storage (div G)
TTT	Transportation
TTA	Air
TTR	Railway
TTW	Water
TTM	Motor and miscellaneous
TTH	Truck
TTO	Other
TTU	Urban
TTB	Interurban and Rural
TTX	Taxicabs
TTZ	Other
TTP	Pipeline
TST	Storage and warehousing
CUT	Communications and utilities
CIT	Communication
CIR	Radio TV cable
CIB	Carriers and other
CIP	Postal
UTL	Utilities
UTE	Electric power
UTG	Gas
UTO	Water and other
TRD	Trade
TRW	Wholesale
TRR	Retail
FIT	Finance, Insurance Real Estate
FIP	Personal Finance
FDT	Deposit taking
FOT	Other
FIS	Insurance
FIX	Royalties and Imputed Rent
FRY	Royalties
FHS	Imputed Rent
SVC	Community business and personal services
SVB	Business
SBO	Other business services
SBB	Professional business services
SBA	Advertising services
SED	Education
SHE	Health and social

SHS	Hospitals
SPH	Physicians and others
SAF	Accommodation and food
SVO	Other services
SRA	Recreation and amusement
SVP	Personal
TLN	Non-Business
REN	Mining
MAN	Manufacturing
FON	Logging and forestry
TSN	Transportation and Storage
TTG	Highway Maintenance
CIN	Communications
UTN	Utilities, Water
FIN	Finance, Insurance
SVN	Services
SBN	Business
SEN	Education
SHN	Hospitals
SHI	Health Institutions
SRN	Rec and Amusement
SPV	Private Households
SRM	Religious
SVM	Other Miscellaneous
ADT	Public Administration
ADF	Federal
ADE	Fed + Defence
AFG	Defence
ADP	Provincial
ADL	Local

For each of the industry categories detailed above, there are a large number of economic attributes endogenously determined. They include:

Measures of Output and other Supply-side Indicators

Gross Output, in constant and nominal dollars
Value Added, or Gross Domestic Product, in constant and current dollars

Investment in Machinery and Equipment in constant and nominal dollars
Investment in Structures in constant and nominal dollars
Capital Stock of Machinery and Equipment in constant dollars
Capital Stock of Structures in constant dollars
Scrappage of Machinery and Equipment Capital Stock in constant dollars
Scrappage of Structures in constant dollars

Measures of Prices and Incomes

Industry Return to Capital
Unincorporated Income
Unit Capital Costs
Rental costs of Capital
Gross Output and Value Added Prices

Measures of Taxes

Commodity Taxes
Corporate Taxes
Subsidies

Employment

Employment on an establishment and labour force survey basis; that is there is a balanced production function for each of the industries since
output, capital stock and employment are defined for each. The input-output system provides material input (and technology) information.

Wages

Supplementary Labour Costs, which are composed of a large number of components, including Unemployment insurance payments, contributions to pension plans and workers compensation, etc.

2.0 Exact Industry Breakdown, and How Calculated, for Models of the Ontario Economy

- Informetrica also has a Regional-Industrial Model which provides estimates for a slightly smaller number of sectors (121 vs. the 159 listed above in 1.0) on the Ontario economy. While it is not clear from the material supplied by the company, it is likely that an average historical distribution of output shipments by province/territory is being used to "allocate" aggregate industrial output ("...such spatial allocation of goods-producing sectors determined from...an export-based view and...detail on final demand available from the national model..."). Certainly the sectoral detail is the richest of any of the models.

WEFA CANADA MODEL [WCCM AND TOMM]

1.0 Exact Industry Breakdown, and How Calculated, for Models of the National Economy

- WCCM does not have the capability to directly generate forecasts to the level of individual industries ("its properties are essentially those of the one-sector macroeconomic models discussed in macroeconomic theory" [WEFA (1991)].

2.0 Exact Industry Breakdown, and How Calculated, for Models of the Ontario Economy

- WEFA's recent vintage Ontario model, TOMM, has a number of Ontario product markets. These include Agriculture, Other Primary, Manufacturing, Construction, Transportation/Communication/Storage, Utilities, Trade, Finance/Insurance/Real Estate, Community/Business/Personal Services, Public Administration/Defense. Seven are completely integrated into the model (Public Adm/Defense has no real market and so is a given, the eighth sector is solved by the solution of seven others - WEFA chooses agriculture which because of marketing boards, etc. also has more exogeneity inherent in it). That is, a production function is specified for each sector; there are factor demands; output markets are modelled; etc.

Appendix D

CEEF Model - Slides

CEEF Background

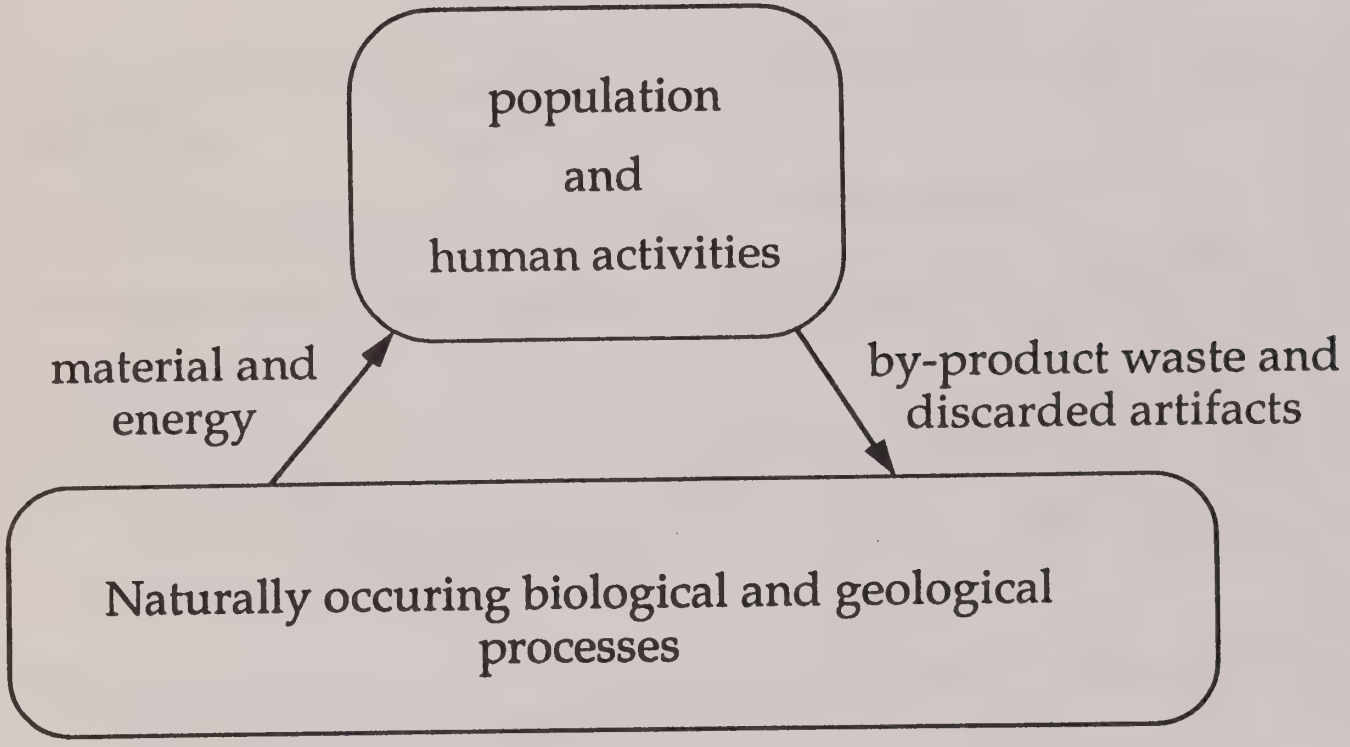
- Project coordinated by the Ontario Conservation Council
- Design completed in September 1990
- Population and Forestry components calibrated in April 1991

CEEF Objectives

- To represent the linkages between human populations and the natural resource base
- To provide an open simulation framework to explore the evolution paths resulting from alternative patterns of societal choices

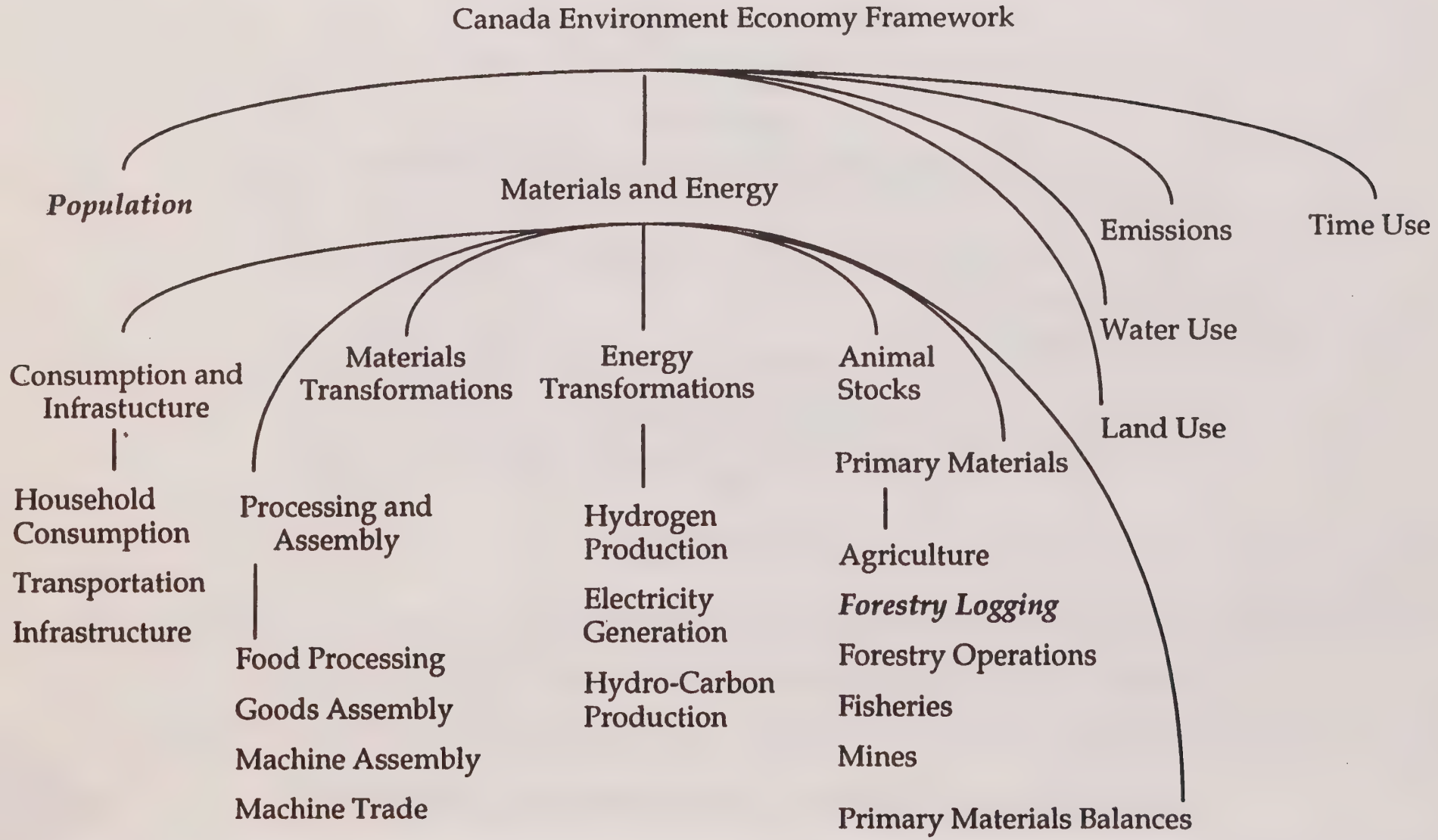
Enhance understanding of the ensemble of possible paths from which societal choices must be made

Canadian Environment Economy Framework



CEEF traces flow of material and energy from the resource base to artifacts required by the population and their return to the environment

Canadian Environment Economy Framework



CEEF Scope

- Represents fifty physical transformation processes
- Includes:
  - population evolution
  - provision of shelter, nutrition and household artifacts
  - assembly of buildings, machines and artifacts
  - tranformation of primary resources into materials and fuels
  - biological processes associated with agriculture, forestry, and fisheries
  - land and water use
  - emissions to the environment